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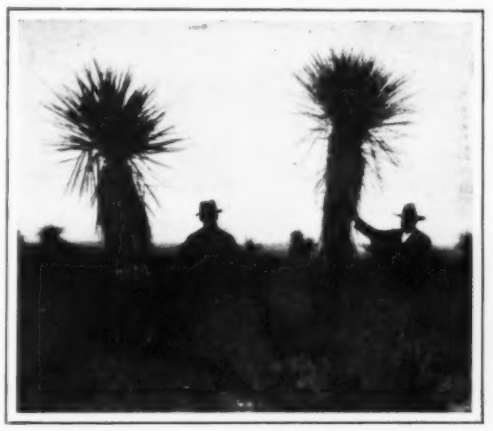
A NEW MEXICAN SUBSTITUTE CORDAGE FIBER.

By Charles Richards Dodge.

Substitute fibers are chiefly useful to mix with the standard commercial kinds where a quality of manufactured product is desired that, while almost as good as the standard, can be sold at a less price. The standard cordage fibers are Manila hemp from the Philippines, and Sisal hemp from Yucatan.

A new substitute fiber, produced in Mexico, is now finding a market in the United States though not as yet in large quantities. It is derived from several species of the yucca family, which grow wild over the more northerly states of the republic, and southward to central Mexico. The fiber is known by several trade names, "*palma istle*," "*pita silvestre*" and "*zamandoque*" being the most common. The name *palma istle*, however, should not be confounded with the true istle, or Tampico, the commercial brush fiber, produced from an agave growing in the same region.

The product sold as *pita silvestre* is secured from a tree-like species of yucca, either *Y. australis*, or *Y. treculeana*, both species abounding in northern Mexico, the source of the fiber being the *cogollo* or central spike of unopened leaves. The annexed cut shows the form of the plant as it grows over vast areas of waste lands in the State of Nuevo Leon, and southward.



TREE-LIKE YUCCAS OF NORTHERN MEXICO.

Fiber is being produced, after crudest methods, at many points, one of the first establishments to exploit the industry being the company La Anglo-Mexicana, with works at Bajan.

The "works" at this place consist merely of a plant with deep wells for a constant water supply, several immense steaming vats or kettles for cooking the leaves, to facilitate extraction of the fiber, a warehouse and a one-story adobe used by the superintendent. Mention should also be made of a "street" of huts—mere pens—where the Indian work-people live. The raw material is gathered at a distance, wherever there is a supply of "trees," and it frequently has to be transported three to five miles to the *rancho*, over a country without roads, by means of ox-carts. Only the leaf-spike, or central cluster of unopened leaves, is used, this being cut out from the mass of expanded leaves which form the crown of the tree. For convenience in handling, the leaf spikes are put up in bundles of fifty.

When the ox-carts come in with their loads, the fires are started under the kettles, which are built into rude masonry with a platform above and fire holes beneath. The bundles of the raw material are thrown into the kettles, covered with refuse, and left to cook until thor-

A FIBER WAREHOUSE.

HUTS OF THE WORK PEOPLE.

THE CULTIVATION AND MANUFACTURE OF MEXICAN SUBSTITUTE CORDAGE FIBER.

oughly steamed and softened (see illustration below). A small army of Indians—men and boys, and even girls—stand ready to receive the material when sufficiently cooked, and as the bundles are broken up and distributed, each carries off a quantity and the work of extraction begins. It is a simple operation and quickly performed. The individual leaves are first stripped from the *cogollo*, smoking hot, and each leaf, held firmly in the hand, is deftly scraped upon a piece of hard wood with a blunt-edged knife. One half of the leaf is scraped on both sides, then reversed and the cleaned end (or fiber) wrapped around a bit of wood for a purchase, when the other end is cleaned in like manner. After the fiber has been sun-dried it is put up in small bunches of a few pounds each and stored in the warehouse, awaiting orders for purchase, when it is baled and shipped.

The fiber runs about 25 to 30 inches in length. In color it varies from a dirty cream white to yellowish, sometimes with a faint greenish hue, when carelessly cleaned. It is harsh to the touch, though it shows fair strength in a lateral strain, but is apt to be somewhat brittle under the torsion test. It is doubtful if it could be used to advantage alone, though it can be mixed with better fibers in the proportion of one to three, and give a substantial manufactured product that can be sold at a less price than the standard product, and for some uses prove almost as serviceable.

In Mexico it is beginning to be considerably employed as a mixture with the true istle, and with maguay fiber, in the manufacture of bags, nearly all of the native bagging being made of cordage fibers, instead of spinning fibers as in the United States.

The kinds locally known as *palma istle* and *zamandoque* are practically the same thing as *pita silvestre*. They are produced from different plants, however, and represent two species of the yucca family, which abound in portions of Tamaulipas and San Luis Potosi, the first named being extracted from *Samuella carnerosana*, and the second from *Hesperaloe funifera*. The name *palma istle* is sometimes given to the fiber of both species indiscriminately.

I have been informed that a species of yucca growing in the state of Jalisco, known to the natives as *izote*, yields a finer and more valuable fiber than either of the others mentioned, but I have not heard of the fiber as a commercial proposition, and doubt if it has ever been exploited. Several species of this family of plants are found in the United States, two or three of which might be utilized for fiber, and especially the heavier leaved varieties growing down near the Mexican border. But we are slow to take up new and untried industries in this country, especially in competition with the cheap labor of other countries. The Mexican Indians work for 37 cents per day (about 16 cents in gold), and many for even less, and probably receive all that they earn considering the crude methods employed. In exploiting these lesser fiber industries, it would seem that American enterprise, with American methods and the use of machinery instead of hand labor, might easily overcome differences in wages, and by utilizing certain of these wild products of the soil, some new and profitable, if not large, industries might be built up, particularly in the Southwest.

There is a growing market for substitute fibers. Much of cordage, and particularly twine, is used but once, and in late years there has been a certain demand for cheaper twines. With the standard fibers worth 10 cents per pound in gold, the only possible way in which a cheaper product can be made is to use cheaper fibers, i. e., substitute fibers, many of which, for most purposes, are "almost as good." It may be stated that the finest lariats made in southern Mexico are produced from fibers not known commercially, and which, if they were known, could only rank as substitutes. The meanest of this class of fibers are better than jute for cordage, and they are worth more money, and the product is stronger and more durable.

KETTLES FOR COOKING THE FIBER SUBSTITUTE LEAVES.

THE CULTIVATION AND MANUFACTURE OF MEXICAN SUBSTITUTE CORDAGE FIBER.

THE WORK OF THE COAST AND GEODETIC SURVEY.

THE report of the Coast and Geodetic Survey for 1904 is a record of manifold labors and results which have for their theater of action an area practically coterminous with that of the United States and all its island possessions. The main body of the report contains a detailed account of the wide range of important duties

HESPERALOE FUNIFERA.

devolving upon this Bureau, and in the appendices we have a presentation of discussions and results which must prove of great economical value and interest to surveyors, engineers, navigators, and physicists.

The resurveys and developments imperatively required to show the changes in harbors and approaches due to works of improvement or the ceaseless action of natural causes along the Atlantic, Pacific, and Gulf coasts of the United States, and to meet the ever-increasing demands of our commerce and navy for up-to-date charts, particularly of the waters of Alaska, Porto Rico, Hawaii, and the Philippines, gave constant employment to the eleven vessels available for these duties. The hydrography was prosecuted within the limits of the waters of sixteen States and Territories, and the topography was carried on in nine.

In Alaska the work included the continuation of the survey of Prince William Sound, the survey of Controller Bay, and a deep-sea examination from the Strait of Juan de Fuca to Prince William Sound, preliminary to the laying of a deep-sea cable from Seattle to Valdez. The Porto Rico work was continued in certain bays and harbors, as well as in the development of the conditions in the off-shore waters. In the Philippine Archipelago the Survey has secured the co-operation of the insular government, and a detailed *résumé* shows a most satisfactory progress of the triangulation, hydrographic, topographic, magnetic, and astronomical operations. By utilizing native assistance in the Manila sub-office, twenty-one charts were prepared for publication during the year, and the outcome of the experience with Filipinos as draftsmen, computers, and engravers is the gratifying demonstration that they will prove quite as competent as the Hindoos have been found in the British Indian operations and the Malagassys have proved themselves in the French surveying work in Madagascar.

The reconnaissance for the primary triangulation along the 98th meridian was completed to the Canadian border, and a scheme was extended eastward connecting this work with the triangulation of the Mississippi River Commission. The execution of the primary triangulation in the Dakotas and Texas was prosecuted at a rate which surpassed even the notable record which had already secured an enviable reputation for the geodetic operations along the 98th meridian, the total extension amounting to 300 miles (500 kilometers). An equal distinction must be accredited to similar work in California and Oregon, whereon remarkable progress has been made in connecting the Transcontinental Arc work with Puget Sound.

The progress of the magnetic work is shown in detail in Appendix No. 3, which includes a table of results of the magnetic declinations, dip, and intensity of force observed on land and sea during the year, this being supplemented with full descriptions of the magnetic stations occupied and meridian lines observed. A new feature is the inclusion of the observations of the three magnetic elements at sea by the Coast and Geodetic Survey vessels in the course of their regular surveying operations. The paper is replete with matters of interest to the surveyor, the mariner, the geographer, and the geologist. Thus comprehensive examination has been made of certain locally disturbed areas, as, for example, in Douglas Island, Alaska, in the region of the local magnetic pole found in 1900; and the completion of the magnetic survey of Louisiana in co-operation with the State Geological Survey revealed interesting and important results, both as regards the magnetic distribution and the secular variation.

The table contains the magnetic results at 384 land stations distributed over twenty-four States and Territories and two foreign countries. The table of sea results contains 52 entries of magnetic declination, 34 dips, and 32 values of the total intensity of the magnetic force in the Atlantic and in the Pacific Ocean. The methods and instruments adopted for the sea work, which have thus far proven successful, are described in detail. In a general retrospective consideration of the work of the past five years, it is pointed out that in this period observations have been made at 1,636 stations, of which about one-eighth are points previously occupied by the Survey, and since used for observations to secure data for ascertaining the secular change of the magnetic elements. The work in about a dozen States has been practically completed except for special investigations and secular change observations. During the year a bureau of international research in terrestrial magnetism has been created by the Carnegie Institution of Washington, with the inspector of the magnetic work of the Coast Survey in charge, as director, and the co-operation thus insured is certain to prove extremely profitable in results.

The determination of the longitude of Manila from San Francisco, thus completing the first longitude circuit of the earth, was one of the astronomical events of the year, and in Appendix No. 4 is a comprehensive illustrated report on the various instruments and operations used in the undertaking, with a comparative *resumé* of the various links and results from which the longitude of Manila had been determined from the westward. The generous co-operation of the Commercial Cable Company, through whose patriotic enterprise the work was made feasible, is gratefully acknowledged. The results of the determinations from the eastward and westward differ only by 0.006s., or about 8.8 feet. The other results of this expedition are the determinations by the telegraphic method of the longitudes of Honolulu and Midway and Guam Islands.

The third attempt at representing the tide for the world at large, the first having been made by Whewell and Airy and the second by Berghaus, is described in Appendix No. 5. The advancement in recent years of the general use of the harmonic analysis, and the greatly improved tidal data that are now obtainable for such a great part of the globe, co-ordinate to make a new presentation of this subject very opportune. The theoretical discussion of the problems involved, the wide range of data and authorities consulted and referred to, the graphic presentation of the co-tidal lines, the results presented, and the conclusions deduced, make a most suggestive paper, and one which will be highly interesting to all students of the subject.

The results of the precise leveling operations for the year are published in Appendices Nos. 6 and 7, which submit them in a detail that makes them immediately available for the requirements of surveyors and engineers. These extend the precise level net, as previously published, six hundred miles to the westward, from Red Desert, Wyoming, to Owyhee in eastern Idaho; and from Holland, Texas, two hundred miles southwest, to Seguin, Texas. An interesting feature is an account of the change in the manner of support for the leveling rods, with the comparative discussion of the old and the new methods, and the consequent confirmation of the importance of the new system.

The account of operations submitted by the assistant in charge gives the story of the work of the various computing, drawing, engraving, and chart divisions of the office, in which the results of the field work are discussed or prepared for the publications and charts wherein they are placed at the service of the public.

A full account of the first recording transit micrometer devised for use in the telegraphic longitude determinations of the Coast and Geodetic Survey is submitted in Appendix No. 8, with an account of the exhaustive tests it was subjected to, and a recapitulation of the results of experience with this form of instrument, mainly in Europe, during the last thirteen years. The results of these experiments indicate that with the transit micrometer the accuracy of telegraphic longi-

tudes may be considerably increased if desirable, or the present standard of accuracy may be maintained at much less cost than formerly.

The results of all triangulation in California south of the latitude of Monterey Bay are printed in the concluding appendix in full, including descriptions of stations as well as their latitudes and longitudes and the lengths and azimuths of the lines joining them. In compact and convenient form there is given all the information in regard to this triangulation that is needed by an engineer or surveyor who wishes to utilize the results in controlling and checking surveys or in constructing maps or charts. The locations of more than 1,300 points are accurately fixed by this triangulation.

The report, in addition to the details of the foregoing operations and results, contains a record of a wide range of important work for which the aid of the Survey was sought because of the special training of its officers. The Superintendent attended the Fourteenth General Conference of the International Geodetic Association as delegate for the United States, and maintained direction of the observatories at Gaithersburg, Maryland, and Ukiah, California, supported by the International Geodetic Association for the purpose of measuring the variations of latitude; he was also detailed for duty in connection with the presentation of the case of the United States before the Alaska Boundary Tribunal, being assisted by one of the officers of the Survey. As Commissioner of the United States he continued the work of remarking the boundary line between the United States and Canada from the Rocky Mountains westward, two of the officers of the Survey being employed in the field; and as Commissioner of the United States in the International Delimitation Commission he inaugurated the work of marking the boundary between Alaska and Canada, one of the parties being under the direction of an assistant of the Survey. One officer continued on duty as a member of the Mississippi River Commission. One officer having completed the field work of the survey of Mason and Dixon's line, the boundary between Maryland and Pennsylvania, was then detailed to prepare the maps and report showing the results of the work. Another officer, at the application of the municipal authorities, remained in charge of the triangulation of the Greater New York territory; and one representative of the Survey, in co-operation with the Louisiana Oyster Commission, continued the survey of the natural oyster beds and reefs for the State of Louisiana.

BLUEBERRY CULTURE.

IN grazing sections throughout the West an old and well-known custom is that of burning the dry grass to improve the next year's pasture. Formerly the fires were allowed to spread and burn themselves out at will, and the practice resulted in great forest destruction. Happily for the forests, the burning is now more carefully done when it is done at all, and on the whole the custom is falling into disuse. In Maine a practice of burning exists which is local to that State, is novel in character, and has nothing to do with grazing. The burning is to assist blueberry culture by causing the bushes to sprout vigorously and clearing the ground of other growth.

About 1870 a factory for canning blueberries was located in Maine, and as it prospered it was followed by others. In 1885 and again in 1899 similar factories and canning companies were established, until to-day blueberry raising and canning is an important industry in that State. To supply the increasing demand blueberry bush areas have been constantly enlarged, until now "blueberry barrens" cover some 2,600 acres in Hancock and Washington counties.

A century ago these "blueberry barrens" were, for the most part, covered by a dense forest, chiefly of white pine and spruce. The forest was thinned by lumbering the pine, and the increased amount of light permitted new kinds of undergrowth to get a foothold. Fire, as almost invariably happens, followed the lumbering, the rest of the original stand was destroyed, and the undergrowth was still further altered, a great variety of valueless underbrush and weeds taking possession of the ground, together with a stand of birch, popple, red maple, and other hardwood seedlings. As the fires continued to occur this hardwood growth became scrubby and was finally entirely eliminated, and the ground became a true barren, covered with a growth of blueberry bushes, sweet fern, brake, bunchberry, goldenrod, and sheep laurel. With the ground in such condition its best use is for blueberry culture.

The blueberry owner divides his land into three portions; each year he picks the berries from one portion, burns another portion, and allows the third to rest. The first year after the land is burned over the blueberry bushes sprout and grow a few inches. The second year they yield a full crop of berries. The third season the crop is small and of little value, and the bushes reach a condition in which they can be burned most effectively.

Under this system of blueberry culture the land does not "run out" with constant use for the same crop. Where the burning has been properly done, the same tracts have grown blueberries continuously for fifty years without showing any decrease in the yield. But if the land is burned over at the wrong time of the year, or the roots of the bushes are badly injured by fire, many years are required to restore the productive capacity of the tract. The best time for burning is when the melting snow leaves the ground wet and the tops of the bushes dry. After May 10 burning is very injurious, unless the spring is exceptionally late.

The canning companies own most of the blueberry lands in Maine, except some small 25 or 50 acre private holdings. Pickers from company lands get 3 cents a quart, while private owners receive about 6 to 8 cents a quart for their berries. The picking season lasts six weeks. A rapid picker makes from $4 to $8 a day; if he has a large family to help him it is not unusual for him to make $600 or $800 in the six weeks.

GIRLS EXTRACTING THE FIBER.

This makes the industry very popular among the pickers, and increases the danger that forest fires will be set or permitted to burn through good timber in order to increase the extent of blueberry barrens.

In addition to the 2,600 acres of present barrens, there are in Hancock County over 5,000 acres which have been reduced almost to a barren condition. Here, if necessary, this industry could be profitably extended. But when lumbering and fires have not materially depleted the forests, the land should be continued under forest cover and the stand improved. The opportunity is ample for a proper extension of blueberry culture without invading valuable forest lands, which should be protected from fire. The wisest policy is to utilize the present blueberry barren areas to the fullest extent, and not to encroach further upon the forests, except as the growth of the industry makes it profitable to take old cut-over lands for this purpose.

MYSTERIOUS WHITE RACES.

By L. E. NEAME.

THE idea that in remote parts of the tropics, amid the dark-skinned races, there exist mysterious isolated white tribes bearing a strong resemblance to Europeans has long possessed a curious fascination for the Old World. The early adventurers in Central and Southern America brought home many tales of extraordinary cities beyond the mountains, and vague stories afloat in South Africa thirty or forty years ago furnished Mr. Rider Haggard with a theme for one of his best-known novels, "Allan Quatermain."

Similar legends are met with in almost all the less-explored parts of the globe, and they have always certain features in common. The isolated white peoples almost invariably inhabit a mountainous region in a vague "interior"—always the "just beyond"; they hold aloof from the surrounding races; they are seldom seen, and yet are definitely stated to be more civilized and better educated than the darker masses whom they avoid. Who they are and whence they came no one knows; native fables afford no explanation. Once it was thought that forgotten white explorers might have built up unknown kingdoms in the wild places of the earth. But upon examination these theories vanish as rapidly as do the white tribes themselves, and the ultimate explanation is almost prosaic.

Yet so strong a hold has the idea gained that even at the beginning of the twentieth century the possibility of the existence of a genuine white race is not altogether scoffed at. It is less than two years ago that an American officer engaged in the operations against the Moros in the Philippines collected apparently substantial evidence relating to a mysterious white tribe in the island of Mindanao. The mountainous district in the center of this island has never been explored, and even the coast is not well known. But along the seaboard many stories are told of the fierce white people who have their home in the forest-clad mountains of the interior. Eye-witnesses depose to having seen a strange, fair-complexioned girl loitering near a coast village, but who fled toward the hills as soon as she was addressed. Other men and women of a light-complexioned race are said to have been seen by more venturesome natives who were bold enough to approach the wild mountain district. The United States officer was so impressed that he determined to conduct an exploring party across the center of the island. But apparently the mysterious white folk had vanished, for the world has as yet heard nothing of his search being crowned with success.

Arabia, however, can with more reason boast of a white tribe. For years stories of such a race have been told in the Persian Gulf, and the Rev. S. M. Zwemer, an American missionary stationed at Muscat, alluded some time ago to "coffee-house babble in eastern Oman concerning a mysterious race of light-complexioned people who live somewhere in the mountains, shun strangers, and speak a language of their own." Various theories have been propounded to explain the fable; but probably the explanation is to be found in the narrative of a journey made in Oman in 1876 by Col. S. B. Miles, published some time ago in the Geographical Journal. Col. Miles, in the course of his travels nearly thirty years ago, came across a town named Sheraizi in the heart of the Green Mountains. This strange place was perched like an eagle's nest on the top of a great cliff, and was inhabited by a people of lighter skin than the rest of the tribes of the interior. They rarely descended to the plains, and refused to mix or intermarry with the Arabs. Colonel Miles found they were the descendants of a portion of the Persian army which invaded Oman in the tenth century. The isolation of the town and the curious behavior of its people through so many generations would undoubtedly give rise to exaggerated stories in the bazaars on the distant coast, and in this case the origin of the fable may be regarded as fairly certain.

Unfortunately for the romance of the world it seems practically impossible for stories of this character to have the origins novelists would wish. The world is comparatively small to-day. The trail of the explorer is over every land from Paraguay to Tibet. Forbidden lands are entered; hidden cities exist only in the imagination of the fictionist. In a period when trains run to Bokhara and the Great African Lakes, when the tourist appears at Khartoum, and Lhassa itself is threatened, there is no room for a mysterious white race. Even the Dark Continent is no longer allowed to have its mysteries. The photographer sits on the battered walls of Kano, the Fulani emperors have passed away.

One may no longer believe in the existence of a strange white people in the heart of Equatorial Africa.

TRANSPORTATION OF FIBER BY OX CARTS, NORTHEASTERN MEXICO.

THE CULTIVATION AND MANUFACTURE OF MEXICAN SUBSTITUTE CORDAGE FIBER.

Mr. Rider Haggard's splendid race are probably only the Ba-hima originally discovered by Speke in southwestern Uganda. At least, Sir Harry Johnston claims to have discovered in them the clue to many of the mysterious white race legends found in the Dark Continent. He was engaged in nothing more thrilling than a tour of inspection to Ankole when he came across them. They are of a very light complexion, and are the "aristocrats" of this region. Sir Harry Johnston says they are "obviously descended from a Gala, Somali, or other Hamitic stock," and adds that some of them are more like Egyptians than is the case with Galas and Somalis. Romance disappears before the tread of the explorer. The Dark Continent is dark no more.—Chambers's Journal.

THE DEVELOPMENT OF THE THEORY OF ELECTROLYTIC DISSOCIATION.*

By PROF. SVANTE ARRHENIUS, Stockholm, Sweden.

AT first sight nothing seems to be more evident than that everything has a beginning and an end, and that it is possible to divide everything. Nevertheless, the philosophers of antiquity, especially the Stoicist, concluded, on purely speculative grounds, that these opinions are not at all necessary. The wonderful development of science has reached the same conclusion as these philosophers, especially Empedocles and Democritus, who lived about 500 years B. C., and for whom the ancients had already a vivid admiration.

Empedocles professed that nothing is made of nothing, and that it is impossible to annihilate anything. All that happens in the world depends upon a change of form and upon the mixture or the separation of bodies. Fire, air, water, and earth are the four elements of which everything is composed. An everlasting circulation is characteristic of nature.

The doctrine of Democritus still more nearly coin-

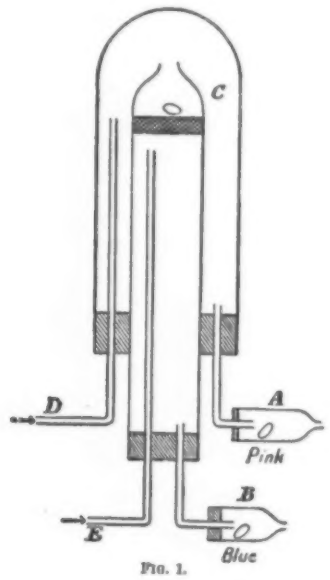


FIG. 1.

cided with our modern views. In his opinion bodies are built up of indefinitely small indivisible particles, which he called atoms. These are distinguished by their form and magnitude, and also give different products by their different modes of aggregation.

This atomic theory was revived by Gassendi about 1650, and then accepted by Boyle and Newton. The theory received a greatly increased importance by the discovery by Dalton of the law of multiple proportions. For instance, the different combinations of nitrogen with oxygen contain, for each unit weight of nitrogen, 0.57, 1.14, 1.72, 2.29 or 2.86 unit weights of oxygen.† Between these combinations there is no intermediate proportion. This peculiarity is characteristic of chemistry in contradistinction to physics, where the more simple continuous and gradual transition from one state to another prevails. This difference between the two sister sciences has often caused controversies in the domain of physical chemistry. The occurrence of discontinuous changes and of multiple proportions has frequently been assumed, when a closer investigation has found nothing of the sort.

The law of multiple proportions is the one fundamental conception upon which modern chemistry is built up. Another is the law of Avogadro, which asserts that equal volumes of different gases under like conditions of temperature and pressure contain the same number of molecules. This conception, dating from the beginning of the nineteenth century, was at first strongly combated, and it was its great value in explaining the new discoveries in the rapidly growing domain of organic chemistry which led to its general acceptance in the middle of the past century, after Cannizzaro had argued strongly in its favor.

There were, however, some difficulties to be removed before Avogadro's law could be accepted. For instance, it was found that the molecular volume of sal-ammoniac, NH_4Cl, in the gaseous state was greater than might be expected from its chemical composition. This led to the supposition that the molecules of sal-ammoniac when in the gaseous state are partially decomposed into ammonia, NH_3, and hydrochloric acid, HCl. Indeed Von Pebal and Von Than succeeded in showing that this really happens. They used an apparatus that is shown in the annexed figure (Fig. 1). Two coaxial tubes are placed the one inside the other by means of a cork. The outer tube was closed at its upper end; the inner one was open and contained at *C* a diaphragm of asbestos and above that a piece of sal-ammoniac. The upper end was heated by an air-bath, so that the piece of sal-ammoniac was volatilized. After this a current

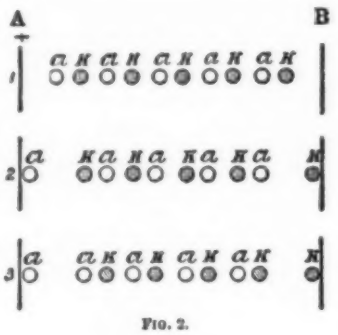


FIG. 2.

of hydrogen was led through both glass tubes *D* and *E*. Now ammonia diffuses more rapidly than hydrochloric acid; if, therefore, the vapor of sal-ammoniac is partially decomposed into ammonia and hydrochloric acid, we should expect that above the asbestos diaphragm there would be an excess of hydrochloric acid and beneath it an excess of ammonia. This Von Pebal showed to be the case. The hydrogen-current from *D* showed an acid reaction on a piece of litmus-paper in *A*, and that from *E* showed an alkaline reaction on a similar piece of litmus-paper placed in *B*. It was objected that the decomposition might possibly be caused by the asbestos of the diaphragm, or by the hydrogen. Von Than, therefore, made a diaphragm of sal-ammoniac, and substituted nitrogen for hydrogen, but the effect was the same.

These experiments were performed in the years 1862 and 1864. They were based on the doctrine of dissociation, which was at that time (1857) worked out by Ste. Claire-Deville, and developed by his pupils. From the most ancient times use was made of the fact that limestone at high temperatures gives off carbonic acid, and that quicklime remains. This and similar processes were studied by Ste. Claire-Deville. He found that the same law is valid for the pressure of carbonic acid over limestone and for the pressure of water vapor over liquid water at different temperatures. On these fundamental researches the theory of dissociation was based, a theory which has subsequently played an ever-increasing rôle in chemistry, and whereby a broad bridge was laid between physical and chemical doctrines.

At almost exactly the same time we find in the writings of Clausius on the conductivity of salt solutions the first traces of an idea that salts or other electrolytes may be partially dissociated in aqueous solutions. Buff had found that even the most minute electric force is sufficient to drive a current through a solution of a salt. Now after the scheme of Grotthuss, at that time generally accepted, the passage of the electric current through a solution is brought about in such manner that the conducting molecules, e. g., of potassium chloride (KCl), are divided into their ions, which combine again with one another in the following manner: At first, as the current is closed, the electrode *A* becomes positive and the electrode *B* negative. All the conducting molecules KCl arrange themselves so that they turn their positive ions (K) to the negative electrode *B*, and their negative ions (Cl) to the positive electrode *A*. After this, one chlorine ion is given up at *A* and one potassium ion at *B*, and the other ions recombine, so that the K of the first molecule takes the Cl of the second molecule, and so on (Fig. 2). Then the molecules turn round under the influence of the electric force, so that we get the scheme 3 and a new decomposition can take place. This represents the Grotthuss scheme, that supposes continuous decompositions and recombinations of the salt molecules.

As such exchanges of ions between the molecules take place even under the influence of the weakest electromotive forces, Clausius concluded that they must also take place if there is no electric force, i. e., no current at all. In favor of his hypothesis he pointed to the fact that Williamson, as far back as 1852, in his epoch-making theory of the formation of ethers, assumed an analogous exchange of the constituents of the molecules. At this exchange of ions it might sometimes, though extremely rarely, happen that an ion becomes free in the solution for a short time; at least such a conception would be in good agreement with the mechanical theory of heat, as it was developed by Krönig, Maxwell, Clausius and others at that time.

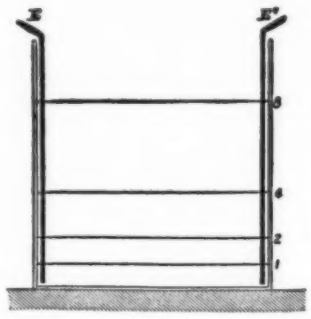


FIG. 3.

In the meantime, Bouty, and particularly Kohlrausch, worked out the methods of determining the electric conductivity of salt solutions. In 1884 I published a memoir on this subject. I had found that if one dilutes a solution—e. g., of zinc sulphate—its conductivity per molecule, or what is called its molecular conductivity, increases not infinitely, but only to a certain limit. We may figure to ourselves an experiment performed in the following manner (Fig. 3): In a trough with parallel walls there are placed close to two opposite sides two plates of amalgamated zinc, E E_1. On the horizontal bottom of the vessel there is placed a layer of solution of zinc-sulphate that reaches the level 1. The conductivity may be k_1. After this has been measured we pour in so much water, that after stirring the solution the level reaches 2, which lies as much above 1 as this lies above the bottom. The conductivity is then found to be increased, and to have the value k_2. Increasing in the same manner the volume by addition of pure water until it is doubled, the level 4 is reached and the conductivity is found to be greater than in the previous case—say k_4. So we may proceed further and further; the conductivity increases, but at the end more slowly than at the beginning. We approach to a final value k_∞. This is best seen in the next diagrams, which represent the newer determinations of Kohlrausch (Figs. 4, 5).

I explained this experiment in the following manner: The conductivity depends upon the velocity with which the ions (Zn and SO_4) of the molecules ($ZnSO_4$) are carried through the liquid by the electric force, i. e., the potential difference between E and E_1. If this potential difference remains constant, the velocity depends only on the friction that the ions in their passage through the liquid exert on the surrounding molecules. As these, at higher dilutions, are only water molecules, it might be expected that the conductivity would remain constant and independent of the dilution if it be supposed that all molecules, $ZnSO_4$, take part in the electric transport. As experiment now teaches us that the molecular conductivity increases with the dilution, even if this is very high (1,000 or more molecules of water to one molecule of $ZnSO_4$), we are led to the hypothesis that not all, but only a part of, the $ZnSO_4$ molecules take part in the transport of electricity. This part increases with the dilution in the same proportion as the molecular conductivity k. The limiting value k_∞ is approached at infinite dilution, and corresponds to the limit that all molecules conduct electricity. The conducting part of the molecules I called the active part. It may evidently be calculated as the quotient $k : k_\infty$.

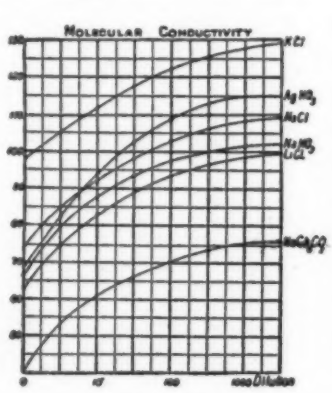


FIG. 4.

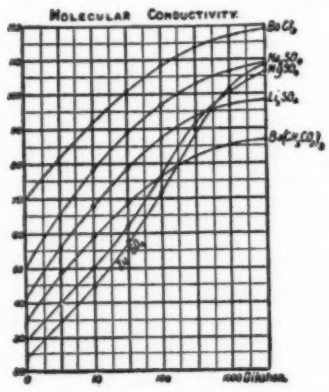


FIG. 5.

If now this new conception were only applicable to the explanation of the phenomena of electric conductivity, its value had not been so very great. But an inspection of the numbers of Kohlrausch and others for the conductivity of the acids and bases, compared with the measurements of Berthelot and Thomsen on their

* Address before the Royal Institution of Great Britain, June 3, 1904.

† To explain this we suppose, in accordance with Dalton, that the molecules of the different combinations of nitrogen with oxygen contain two atoms of nitrogen and one, two, three, four or five atoms of oxygen.

relative strength with regard to their chemical effect, showed me that the best conducting acids and bases are also the strongest. I was thereby led to suppose that the electrically active molecules are also chemically active. On the other hand, the electrically inactive molecules are also chemically inactive. In this connection I would mention the remarkable experiments of Gore, which were easily explained by the new point of view. Concentrated hydrochloric acid, free from water, has no action on oxides or carbonates. Now this hydrochloric acid is almost incapable of conducting the electric current, whereas its aqueous solu-

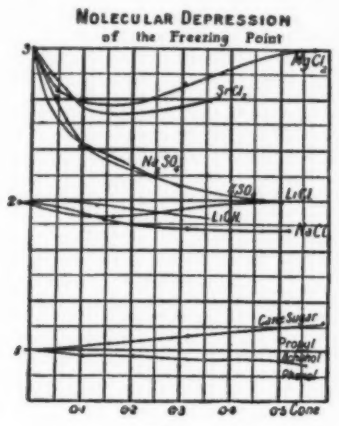


FIG. 6.

tions conduct very well. The pure hydrochloric acid contains, therefore, no (or extremely few) active molecules, and this agrees very well with the experiments of Gore. In the same way we explain the fact that concentrated sulphuric acid may be preserved in vessels of iron plates without destroying them, whereas this is impossible with the diluted acid.

An unexpected conclusion may be deduced from this idea. As all electrolytes in extreme dilution are completely active, then the weak acids must increase in strength with the dilution, and approach to the strength of the strongest acids. This was soon afterward shown by Ostwald to agree with experiments.

The Norwegian natural philosophers, Guldberg and Waage, had developed a theory according to which the strength of different acids might be measured as well by their power of displacing another acid in solutions as by their faculty to increase the velocity of chemical reactions. Therefore, we may conclude that the velocity of reaction, induced by an acid, would be proportional to the quantity of active molecules in it. I had only a few experiments by Berthelot to demonstrate this proposition, but in 1884 Ostwald published a great number of observations that showed this conclusion to be true.

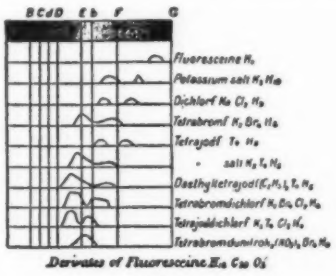
The most far-reaching conclusion of the conception of active molecules was the explanation of the heat of neutralization. As this is much more easily understood by means of the theory of electrolytic dissociation, I anticipate this for a moment. According to this theory strong acids and bases, as well as salts, are at great dilution (nearly) completely dissociated in their ions, e. g., HCl in $\overset{+}{H} + \overline{Cl}$, NaOH in $\overset{+}{Na} + \overline{OH}$ and NaCl in $\overset{+}{Na} + \overline{Cl}$. But water is (nearly) not dissociated at all. Therefore the reaction of neutralization at mixing a strong acid, e. g., HCl with a strong base, e. g., NaOH, both in great dilution, may be represented by the following equation:

$$(\overset{+}{H} + \overline{Cl}) + (\overset{+}{Na} + \overline{OH}) = (\overset{+}{Na} + \overline{Cl}) + HOH;$$

or,

$$H + OH = HOH.$$

The whole reaction is equivalent to the formation of water out of both its ions, $\overset{+}{H}$ and $\overline{OH}$, and evidently in-


B C D E b F G
Fluorescein H2
Potassium salt K2 H10
Dichlorf Na Cl2 H2
Tetrabromf K2 Br4 H8
Tetrajodf Te H8
salt K2 I4 H6
Diethyltetrajodf (C2H5)4 I4 H4
Tetrabromdichlorf K2 Br4 Cl2 H6
Tetrajoddichlorf K2 I4 Cl2 H6
Tetrabromdunitrok2(NO2)2 Br4 H6

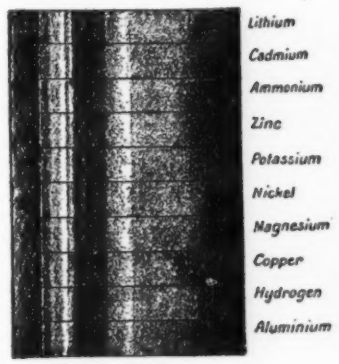
Derivates of Fluorescein H_{10} C_{20} O_5

FIG. 7.

dependent of the nature of the strong acid and of the strong base. The heat of any reaction of this kind must, therefore, always be the same for equivalent quantities of any strong acids and bases. In reality it is found to be 13,600 cal. in all cases. This thermal equality was the most prominent feature that thermochemistry had discovered.

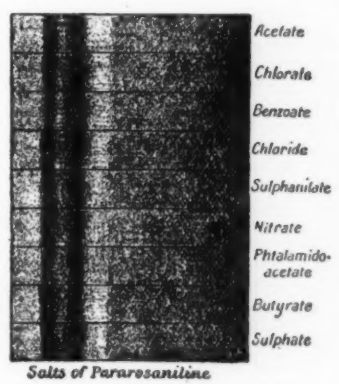
It was now asked in what respect the active state of the electrolytes differs from the inactive one. On this question I gave an answer in 1887. At that time Van't Hoff had formulated his wide-reaching law that the molecules in a state of great dilution obey the laws that are valid for the gaseous state, if we only replace the gas-pressure by the osmotic pressure in liquids. As Van't Hoff showed, the osmotic pressure of a dissolved body could much more easily be determined by help of a measurement of the freezing point of the solution than directly. Now both the direct measurements made by De Vries, as also the freezing points of electrolytic solutions, showed a much higher osmotic pressure than might be expected from the chemical formula. As, for instance, the solution of 1 gramme-molecule of ethylic alcohol—$C_2H_5OH = 46$ grammes—in one liter gives the freezing-point —1.85 deg. C., calculated by Van't Hoff the solution of 1 gramme-molecule of sodium chloride—NaCl = 58.5 grammes—in one liter gives the freezing-point $-3.26 = -1.75 \times 1.85$ deg. C. This peculiarity may be explained in the same manner as the "abnormal" density of gaseous sal-ammoniac, viz., by assuming a partial dissociation—to 75 per cent—of the molecules of sodium chloride. For then the solution contains 0.25 gramme-molecule of NaCl, 0.75 gramme-molecule of Cl and 0.75 gramme-molecule of Na; in all, 1.75 gramme-molecules. Now we have seen before how we may calculate the number of active molecules in the same solution of sodium chloride, and we find by Kohlrausch's measurements precisely the number 0.75. From this I was led to suppose that the active molecules of the salts are divided into their ions. These are wholly free and behave just as other molecules in the solutions. In the same manner I calculated the degree of dissociation of all the electrolytes that were determined at that time—they were about eighty—and I found in general a very good agreement between the two methods of calculation. In a few instances the agreement was not so good; I therefore made new determinations for these bodies and some others. The new determinations were all in good conformity with the theoretical prevision.

The next figure (Fig. 6) shows the freezing-points of some solution of salts, and of non-conductors. As abscissa is used the molecular concentration of the bodies, as ordinates the molecular depression of the freezing-point, divided by 1.85, that should be expected if no dissociation took place. As the figure shows, all the curves for the non-conductors—in this case cane-sugar, propyl-alcohol and phenol—converge toward unity with diminishing concentration. At higher concentrations there occur deviations from the simple law.



Permanganates

FIG. 8.



Salts of Pararosaniline

FIG. 9.

As examples of binary electrolytes are chosen LiOH, NaCl and LiCl—their curves all converge toward the number 2. As ternary electrolytes are chosen K_2SO_4, Na_2SO_4, $MgCl_2$ and $SrCl_2$, they are decomposed into three ions, and their curves therefore all converge toward the number 3.

As I had taken a step that seemed most adventurous to chemists, there remained to investigate its chemical and physical consequences. The most general and wide-reaching of these is that the properties of a highly attenuated solution of an electrolyte ought to be additive, that is, composed of the properties of the different ions into which the electrolyte is decomposed. This was already known to be the case in many instances, and Valson had to this end tabulated his "modules" by the addition of the one value for the negative to the other for the positive ion, we may calculate the properties of any electrolyte composed of the tabulated ions. In this way we may treat the specific weight (Valson), the molecular conductivity (law of Kohlrausch), the internal friction (Arrhenius), the capillarity (Valson), the compressibility (Röntgen and Schneider), the refractive index (Gladstone), the natural rotation of polarization (law of Oudemans), the magnetic rotation of polarization (Perkin and Jahn), the magnetization (Wiedemann), and all other properties of the electrolytes hitherto sufficiently studied.

The most important of these additive properties are those of which we make use in chemical analysis. As is well known, it is generally true that chlorides give a white precipitate with silver salts. It was said formerly that silver salts are reagents for chlorine. Now we say that silver ions are reagents for chlorine ions. This expression is better than the old one, for neither all silver salts, e. g., potassium silver cyanide and many other compounds of silver, nor all chlorine compounds, e. g., potassium chlorate and many organic chlorides, give this characteristic reaction. The experiment succeeds only with such silver and chlorine compounds as are in a measurable degree decomposed into silver and chlorine ions. Ostwald has treated this question comprehensively, and in this way he has given a rational exposition of the general phenomena of analytical chemistry. To this fact belong, also, the poisonous effect of some salts; this effect may be considered as a special physiologically chemical reaction of the chemical compounds. On this point there are many valuable researches by Krönig and Paul, Clarke and others.

A property that is of physical character, but is much used by the analytical chemist, is the color of the solutions. It has been subjected to a rigorous research by Ostwald. At first we will trace how a compound, e. g., fluoresceine, $H_{12}C_{20}O_5$, behaves if one replaces its hydrogen atoms by other atoms, e. g., metals, iodine, bromine, or atomic groups (NO_2). The curves in the next figure (Fig. 7) indicate absorption-bands in the spectra of the corresponding compounds. A replacement of K_2 for H_2 in the fluoresceine itself alters the absorption-spectrum in a most sensible manner. This depends upon the property that the fluoresceine is dissociated to a slight extent, which is in striking contrast to the permanganic acid which will be discussed immediately. Instead of a single absorption-band in the blue in the first case, we find two absorption-bands in the blue-green and the green part of the spectrum for the second. A similar observation may be made for the tetraiodine-fluoresceine and its potassium salt. In general the figure shows that the spectrum is changed in a very conspicuous manner at the smallest chemical change of the molecule.

It might therefore be expected, after the old manner of view, that the replacement of hydrogen by a metal in permanganic acid, or of one acid rest by another in the salts of para-rosaniline, would wholly change the character of the spectra. This is not the case, as Ostwald has shown. The spectra are wholly unchanged, as Figs. 8 and 9 show. The spectra are all produced by the same substance, viz., the permanganate-ion, in the one, the para-rosaniline-ion, in the other case. Only in the case of the para-rosaniline salts we observe that the absorption is sensibly weaker in some cases than in others. The weakening depends upon the hydrolysis of the salts of the weak acids, e. g., acetic and benzoic acids. This research of Ostwald shows in a most convincing manner the correctness of the views of the theory of electrolytic dissociation.

It has been objected to this theory that, according to it, it might be possible by diffusion to separate both ions, e. g., chlorine and sodium from another in a so-

lution of sodium chloride. In reality chlorine diffuses about 1.4 times more rapidly than sodium. But the ions carry their electric charges with them. Therefore if we place a solution of sodium chloride in a vessel and pour a layer of pure water over it, it is true that in the first moments a little excess of chlorine enters the water. By this the water is charged negatively, and the solution under it positively, so that the sodium ions are driven out from the solution with a greater force than the chlorine ions. As soon as that force is 1.4 times greater than this, the chlorine ions travel just as slowly as the sodium ions. It is not difficult to calculate that this case happens as soon as the chlorine ion is contained in the water in an excess of about the billionth part of a milligramme over the equivalent quantity of sodium. This extremely minute quantity we should in vain try to detect by chemical means. By electrical means it succeeds pretty well, as Nernst has demonstrated experimentally for his concentration elements. Therefore, the said objection is valid against the hypothesis of a common dissociation of the salts, but not against a dissociation into ions, that are charged with electricity, as Faraday's law demands. Probably this objection has hindered an earlier acceptance of a dissociated state of the electrolytes, to which, for instance, Valson and Bartoli inclined.

The gaseous laws that are valid for dilute solutions have made the calculation of the degree of dissociation possible in a great number of cases. The first application of that nature was made by Ostwald, who showed that the dissociation equilibrium between the ions and the non-dissociated part of a weak acid obeys very nearly the gaseous laws. The same was afterward demonstrated to be true for weak bases by Bredig. The strongly dissociated electrolytes, chiefly salts, exhibit even in dilute solutions (over 0.05 normal) anomalies, that are not yet wholly explained. Prof. Jahn, of Berlin, is at work upon this most interesting question.

The equilibrium between a greater number of electrolytes has been investigated by myself, and found to be in good agreement with the theoretical previsions. This section includes the questions on the weakening of an acid by addition of its salts, and on the so-called

avidity of the different acids, that is, the proportion in which two acids divide a base at partial neutralization. Calculation gives very nearly the numbers observed experimentally by Thomsen and Ostwald. For heterogeneous equilibria between electrolytes the theory is worked out by Van't Hoff and Nernst, who have in this way elucidated the common method to precipitate salts used in analytical chemistry.

By help of the gaseous laws it is also possible to determine the heat evolved at the dissociation of a weak acid or base, and in this way I was able to calculate the heat of neutralization of acids and bases in a general manner. In an analogous way, Fanjung calculated the changes of volume at dissociation of a weak acid or base and at the neutralization of these bodies. All these calculations gave values very nearly agreeing with the observed ones.

An important rôle is played by the water, which may be regarded as a weak acid or base. By its electrolytical dissociation it causes the hydrolysis of salts of weak acids and bases. By observation of the hydrolysis, it was possible to calculate the electrolytic dissociation of water, and this quantity was soon after determined by electrical measurements by Kohlrausch and Heydweiller in perfect agreement with the previous calculations. For physiological chemistry this question is of the greatest importance, as is confirmed by the experimental results of Sjögvist and others. Also for the explanation of volcanic phenomena, the concurrence between water and silicic acid at different temperatures has found an application.

The catalytic phenomena in which acids and bases are the chief agents have been investigated by many observers, and it has been found that the catalytic action depends on the quantity of free hydrogen or hydroxyl ions that are present in the solution. To this review, that makes no pretension to be complete, may also be added the wide-reaching researches of Van't Hoff, Ostwald, and especially Nernst, on the electromotive forces produced by the ions. By these investigations we have now acquired an explanation of the old problem of the manner in which electromotive forces in hydro-electric combinations are excited.

I have now traced the manner in which the idea of electrolytic dissociation grew out of our old conception of atoms and molecules. Sometimes we hear the objection that this idea may not be true, but only a good working hypothesis. This objection, however, is in reality no objection at all, for we can never be certain that we have found the ultimate truth. The conception of molecules and atoms is sometimes refuted on philosophical grounds, but till he has got a better and more convenient representation of chemical phenomena, the chemist will, no doubt, continue to use the atomic theory without scruple. Exactly the same is the case for the electrolytic dissociation theory.

This theory has shown us that in the chemical world the most important rôle is played by atoms or complexes of atoms, that are charged with electricity. The common tendency of scientific investigation seems to give an even more preponderating position to electricity, the mightiest agent of nature. This development is now proceeding very rapidly. Already we see not only how the theory of electrons of J. J. Thomson, in which matter is reduced to a very insignificant part, is developing, but also how efforts are made with good success to explain matter as only a manifestation of electrodynamic forces (Kaufmann-Abraham).

To these modern developments the work of British men of science has contributed in the most effective manner. The bold previsions of Sir William Crookes seem to be rapidly acquiring a concrete form, to the great benefit of scientific evolution.—Popular Science Monthly.

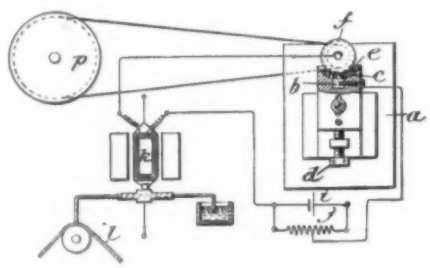
OIL-FILM RECEIVER FOR SPACE TELEGRAPHY.

COHERERS for space-telegraph receivers have hitherto depended on the imperfect contact due to the natural film of oxide or other material which exists on most metals and which acts as the intervening layer, preventing full conduction between a pair of metal pieces brought into light contact in some random or unmetrical manner. Sometimes a contact between a spring pressing lightly on a point has been utilized. More usually, however, the accidental light and imperfect contact between the particles of a mass of metal filings has been employed. In each case the electrical disturbance due to the impact of ethereal waves has resulted in "coherence" and increased conductivity in the coherer, and "decoherence" has been occasioned by agitation or tapping. All coherers depending upon imperfect or light contact between bodies are subject to variation of sensitiveness and require frequent adjustment or renewal.

Dr. Oliver J. Lodge, of Birmingham, Alexander Muirhead, of Shortlands, and Edward E. Robinson, of Birmingham, England, in a recent United States patent propose to dispense with the use of imperfect contacts in the construction of detectors or receivers and to use a thin film of some insulating material to separate the conducting masses which compose the detector or receiver and to obtain in a definite manner the light pressure desirable when the maximum sensitiveness is required. To this end they employ as the insulating film a thin layer of paraffin oil or similar insulating substance interposed between two metallic or conducting surfaces and frequently renewed, and for the pressure they depend on the hydrostatic pressure of a column of liquid, preferably employing mercury or other conducting fluid as one of the two conductors, the other one being solid and plunged to a given depth in the mercury.

To apply the film of oil, a layer of oil is placed upon the mercury, so that when the solid metal, preferably in the form of a platinum or iron point or a metallic wheel, is immersed to a small depth into the mercury it carries down with it a superficial film of oil. When the platinum or iron point or wheel is immersed into the mercury the depth of immersion must be slight, so that there may be as little capacity as possible between the two conductors, the insulating film employed acting as a perfect insulator or dielectric between the two. The smaller the capacity of the detector or receiver the more sensitive it will be to the ethereal waves. Although it is feasible to receive signals without actual immersion of the point or wheel into the mercury, yet the insulating film in such instance would necessarily be considerably thicker, requiring more battery power to break it down, which is correspondingly undesirable. For this reason it is preferable to obtain a thinner film by immersion, making use of the hydrostatic pressure of the mercury for that purpose and permitting the use of a much lower voltage.

It has been found that so long as a feeble voltage is applied (say three-tenths of a volt or less) the film is strong enough permanently to resist the passage of a current, but that whenever the electro-motive force rises to, say, one volt or more, as it does at once, for an instant, if a spark has occurred in the neighborhood or if electric waves have been received from a distant station, then the film is broken down, easy conduction is caused, and a signal is recorded. To restore the continuity of the film again, motion is sufficient, and one of the simplest plans is to withdraw the metal point from the mercury into the supernatant layer of oil and immediately plunge it back again into the mercury. This withdrawal and reimmersion is very easily accomplished automatically, either by mechanical or electrical means or by the action of the current which the broken-down film itself transmits or otherwise, the reimmersion of the point following instantly on the cessation of the current by the restoration of the film. Obviously this motion may be effected in any appropriate manner, whether by rotation or translation or vibration. For instance, the immersed conductor might be the rim of a rotating wheel, or it might be supported on a vibrating body, such as the prong of a tuning fork, or it might be simply depressed into the mercury and withdrawn therefrom



OIL-FILM RECEIVER FOR SPACE TELEGRAPHY.

by attachment to the siphon-recorder coil or other moving part affected electromagnetically by the signaling current. The passage of a comparatively strong momentary current across the broken-down film is no detriment, since the film, being liquid, can be completely and certainly renewed. The metal used should be clean, free from any film of its own and not liable to amalgamate with mercury. One of these methods is illustrated herewith, showing the receiver attached to a moving wheel.

The conducting part, *f*, is shown in the form of a disk or wheel slightly immersed in the mercury, *b*. The constant rotation of the wheel, effected by such means as a clockwork train, represented diagrammatically at *p*, brings about the restoration of the continuity of the oil film between the wheel and the mercury after the breaking-down action of ethereal waves received from a distance. The amount of pressure of the mercury upon the disk or wheel is regulated by means of the screw, *d*, fixed beneath the trough, *c*, which contains the mercury, so as to raise or lower it, and so regulate the immersion. The film or layer of paraffine oil acting as an insulator is shown at *c*.—Western Electrician.

THE GREATEST ELECTRIC SHOCK ON RECORD.

THIS shock was received, on August 23, 1903, by an Italian named Archimedi Lazzari, from Mantova, Italy. He is a strongly-built man, 36 years of age, and by profession a mechanical blacksmith, in which capacity he worked during the whole of the construction work for the Canadian-American hydraulic plant at Parnahyba, State of Sao Paulo, Brazil.

This company supplies electricity for tramways, light, and power in the city of Sao Paulo, which is 33 kilometers away from the generating station at Parnahyba. The station contains four 1,000-kilowatt, 252-ampere, 2,300-volt, 60-cycle alternators, of the New York General Electric Company's make. The voltage is raised by means of transformers up to 24,000 volts.

A little before the date mentioned, the management decided to change all the iron framework behind the high-tension board to wooden work. It was also found advisable, as additional panels had just been erected, to change over the position of some of the old panels in order to symmetrize the board, thus permitting the high-tension buses to be divided into halves, by means of switches, to facilitate cleaning.

Everything being in readiness at 12 o'clock midnight, on Sunday, August 23, the work was commenced, this being the hour of lightest load. Archimedi was working in his professional capacity. At about 5:10 A. M., the ironwork had been removed and the wooden framing placed in position. The buses had also been divided into halves preparatory to being connected to their respective switches. There are two separate sets of bus-bars, one above the other, either of which can carry the entire load, so that as the work proceeded the current was changed alternately from one set to the other, thus avoiding the necessity of working on live wires. Every precaution had been taken against accidents, and, in fact, it was over-zeal to be cautious which caused the mishap. The buses being divided, and the work being carried on upon the dead section, one of the operators, Thomas W. Bevan, Jr., son of the power-house superintendent, went over to work near the live half. Archimedi, wishing to warn him of his danger, took hold of Bevan junior's wrist, and leaned forward to speak with him; at the same time he had his foot against an anchor bolt of the iron framework which had just been taken down. This bolt was cemented on to the floor of the gallery (the high-tension board being on a gallery), the latter being made of steel rails with brickwork arching between the rails. Archimedi leaned over too far and came too near one of the 24,000-volt bare copper wires, which was one of the secondary leads off the main transformers to the high-tension board. Immediately the current jumped onto his shoulder, passing through his body and out at his feet onto the anchor bolt. Both Archimedi and Bevan, Jr., remained transfixed, while Mr. Bevan, Sr., thinking it was his son who was on the wire, leaped into the air (in order to disconnect himself from the ground) and plunged against his son. The shock pulled both men off the wire, and Archimedi loosened Bevan's wrist, only to fall near the wire again, in almost identically the same position as before, only this time the whole current was passing through his own body, not as before, when a portion must have been shunted through Bevan, Jr. Mr. Bevan, Sr., who was thrown violently on the floor, tried to kick Archimedi's foot from under him, only to find that every time he (Mr. Bevan, Sr.) touched the stricken man's foot, his own legs were shot back with terrific force. Archimedi remained thus until the power was taken off. He must have been fully half a minute under the action of the current. He claims to have been conscious all the time, and says that he felt nothing. In fact, he was able to describe exactly what occurred, and says he felt the power taken off the first time, and then come on again, as he fell the second time near the wire. On the power being taken off he immediately became unconscious, and his mouth had to be opened with the end of a file, and a piece of wood put between his teeth to keep them apart, while his arms and legs were being worked so as to produce artificial respiration. In a little over ten minutes Archimedi was able to walk about on a man's arm. He felt sick and had fearful burns on his shoulder and his foot, but after about six weeks' absence he came back to work and has not missed a day since. Both the Bevans suffered nothing greater than little burns over the body, wherever the current came in contact.

All the men present are willing to vouch as to the place in which Archimedi suffered the shock, namely, on the high-tension gallery, and there are no wires there except bare copper wires, all under a pressure of 24,000 volts.

The writer, who was present (and who at once rushed to the switchboard under the gallery and pulled out the main exciter switches), observed a heavy arc between Archimedi's foot and the anchor bolt, and Bevan, Jr., saw a similar arc formed between his shoulder and the wire. There was apparently, therefore, no actual contact with the wires, and owing to the high resistance of the arcs, the current was greatly reduced in volume. This probably explains the reason why the men were not killed instantly.—W. da F. B. Davids in London Electrician.

A CONTEMPLATED MAGNETIC SURVEY OF THE NORTH PACIFIC OCEAN BY THE CARNEGIE INSTITUTION.

A PROJECT for a magnetic survey of the North Pacific Ocean by the Department of International Research in Terrestrial Magnetism has been favorably acted upon by the executive committee of the Carnegie Institution of Washington, and authorization has been given to begin the work this year. An initial allotment of $20,000 has been made to cover the expenses for the current year.

As is well known, the state of our knowledge of the distribution of the magnetic forces over the greater portion of the earth—the oceanic areas—owing to the paucity of precise data, is exceedingly unsatisfactory. This fact is especially true for that great body of water, the Pacific Ocean, rapidly developing in great commercial importance.

Capt. Creak, for many years superintendent of the Compass Department of the British Admiralty, now retired, says: "The North Pacific Ocean is, with the exception of the voyage of the 'Challenger,' nearly a blank as regards magnetic observations, and I therefore think the magnetic survey proposed will be of great value."

Hence, except for data from occasional expeditions and such as were acquired in wooden vessels a long time ago, the present magnetic charts used by the nav-

igator over this region depend largely upon the observations on islands and along the coasts. Such land observations, however, are rarely representative of the true values because of prevalent local disturbances. It is, therefore, impossible to make any statement as to the correctness of the present charts. The demands of science, as well as those of commerce and navigation, require a systematic magnetic survey of this region under the most favorable conditions possible, and that the work be done under the auspices of some recognized research institution, in order to insure that the scientific aspects of the work receive their adequate recognition.

The eminent physicist and magnetician, Prof. Arthur Schuster, states as his opinion: "I believe that no material progress of terrestrial magnetism is possible until the magnetic constants of the great ocean basins, especially the Pacific, have been determined more accurately than they are at present. There is reason to believe that these constants may be affected by considerable systematic errors. It is possible that these errors have crept in by paying too much attention to measurements made on islands and along the seacoast. What is wanted are more numerous and more accurate observations on the sea itself." Furthermore, the superintendent of the United States Coast and Geodetic Survey, Mr. O. H. Tittmann, says: "There is no doubt in my mind that a survey for that purpose would result in obtaining data of great and permanent value, and that it should be undertaken."

Additional quotations could be given; the above, however, are representative, and show sufficiently the great importance of the proposed work and the fruitful results that may confidently be expected. It is the hope that upon the completion of the magnetic survey of the North Pacific, the means will be forthcoming for extending the survey so as to include other oceanic areas. An effort will furthermore be made to secure the interest and co-operation of all civilized countries, so that we may look forward to the completion of a general magnetic survey of the accessible portions of the globe within about fifteen years. Thanks to the awakening and renewed interest in magnetic work shown on all sides, I fully believe that this hope will be realized.

The matter of prime consideration in magnetic work at sea is the elimination of the effects resulting from the ship's own magnetism, due to her construction and equipment. Such effects are especially troublesome to eliminate when it is proposed to obtain not only the magnetic declination at sea, but also the other magnetic elements (the dip and the intensity of the magnetic force). The plan, therefore, to be attempted this year, as worked out by Mr. G. W. Littlehales, hydrographic engineer of the United States Hydrographic Office, and consulting hydrographer of the Department of Terrestrial Magnetism of the Carnegie Institution, is in brief as follows: "To charter a wood-built, nonmagnetic sailing vessel of about six hundred tons displacement, which starting out in summer from San Francisco, shall pursue a clockwise spiral course embracing the entire North Pacific Ocean. The object of planning such a course is to gain continuous advantage throughout the survey of the dynamical agencies of the atmosphere and the ocean, in passing in succession into each of the five-degree quadrangles into which the chart* is divided, and in which observed values of the three magnetic elements need to be obtained."

"The seasonal shifting of the permanent centers of barometric pressure will cause a variation from month to month of the conditions of wind and current that are represented on this particular chart; but if the departure from San Francisco be taken in the summer, the chain of meteorological events will contribute toward the maximum progress over the course, passing thence along the west coast of America to the vicinity of the Galapagos Islands, thence across the Pacific in latitude between two and three degrees north, thence along the eastern side of the Philippine Archipelago and the empire of Japan, thence eastward in about latitude fifty-two degrees north, thence to the latitude of San Francisco, and thence continuing through the series of areas, bounded by parallels of latitude and meridians of longitude each five degrees apart, lying next on the mid-ocean side of the circuit last made, and proceeding gradually and by successive circuits into the central region of the North Pacific."

The total length of the course marked out is about 70,000 knots; however, each of the first circuits practically closes at San Francisco, so that, if it is found that the method pursued is not the best, the work can readily be terminated or modified. From inquiries made, it would appear that the entire work of observation and reduction can be accomplished in three years. The cost per month of the field work, inclusive of all expenses and services, will approximate fifteen hundred dollars. Counting eight months of continuous service per annum, the total annual outlay is estimated at about twelve thousand dollars.

This project, as the result of careful consideration and solicitation of expert opinion, is believed to be thoroughly feasible. It permits of useful comprehensive results being immediately obtained, and is one which can be interrupted without any important waste of antecedent expense, whenever circumstances may render a discontinuance or a modification of the original plan advisable.

The region it is proposed at present to survey fortunately contains magnetic observatories in requisite number and proper distribution for furnishing the necessary corrections to be applied to the observed magnetic elements in order to reduce them to a common epoch. Thus continuous records of the magnetic variations required for this purpose will be available from the following stations: Sitka, Mexico, Honolulu, Manila, Shanghai, Tokio. In addition it is hoped that there may be soon a magnetic observatory in California or vicinity for lending effective co-operation, and that the German government will continue its magnetic observatory at Apia throughout the period of the survey. Also excellent opportunities for controlling instrumental constants and obtaining required additional data will be afforded by stations on the coasts and on islands.

It should also be pointed out that the plan of the courses as mapped permits ready adjustment of the observed quantities for closed areas, in accordance with the potential hypothesis, and it may even permit to a certain degree the testing of the accuracy of this assumption, though as regards the latter more can be said at the end of a year's work.

While it is not anticipated that any marked irregularities in the distribution of the earth's magnetism will manifest themselves over the deep waters of the Pacific, it may confidently be expected that in the neighborhood of the islands and along the coasts distortions and irregularities will be revealed. With the aid of the results of the detailed magnetic survey of the United States and Alaska, opportunity will therefore be afforded of studying the effect of the configuration of land and water upon the distribution of the magnetic forces. The first circuit, passing as it does along the American and Asiatic coasts, will yield especially interesting results in this respect. Thus, for example, along the Aleutian Islands marked local disturbances will be disclosed. Reports are received frequently from mariners in this region regarding the unsatisfactory behavior of the compass; it is therefore greatly to be desired that a systematic magnetic survey of the waters in this region be made.

L. A. BAUER, Director.

Department Terrestrial Magnetism, Carnegie Institution, Washington, D. C.

* The course to be followed was shown in red ink on a United States Hydrographic Office Pilot Chart of the North Pacific.

EDISON AND HIS EARLY WORK.*

By ARTHUR CHURCHILL.

AT the age of twelve Edison took what may be called his start in life by becoming a train boy on the section of the Grand Trunk Railway traversing central Michigan, where he peddled papers, magazines, nuts, fruits, etc.

While in this capacity he edited, printed, and published a small paper of his own on the train, and called it the "Grand Trunk Herald." It had a circulation of about 300 among the employees of the road. The famous engineer, Robert Stephenson, had a complete file sent him regularly.

Shortly afterward, Edison rescued the son of a station agent from being run over by a train, and as a slight acknowledgment of his services, the father offered to teach him how to telegraph, an opportunity he was quick to take advantage of. Within five months he obtained a situation as an operator, and on one occasion, in sending train dispatches, very nearly caused a collision. Realizing the mistake he had made he took an early opportunity to leave that section of the country. The collision, however, never occurred. Owing to his dislike to routine work, his fondness for reading, and his inventive genius, changes of position were frequent, and he became what is known as a "tramp operator," although reputed to be a very efficient one. One of his first improvements was a recording telegraph, and, as related by himself, originated as follows:

"I worked a 'plug circuit' in the day time at Indianapolis, and got a small salary for doing it. But at night, with another operator named Parmley, I used to receive newspaper reports just for practice. The regular operator was a man named Williams, and as he was given to copious libations, he was glad enough to sleep off the effects, while we did his work for him as well as we could. I would sit down for ten minutes and 'take' as much as I could from the instrument, carrying the rest in my head. Then, while I wrote, Parmley would serve his turn at taking, and so on. This worked well until they put a new man on at the Cincinnati end. He was one of the quickest dispatchers in the business, and we soon found it was hopeless for us to try to keep up with him. Then it was that I worked out my first invention, and necessity was certainly the mother of it. I got two old Morse registers, and arranged them in such a way that by running a strip of paper through them the dots and dashes were recorded on it by the first instrument as fast as they were delivered from the Cincinnati end, and they were transmitted to us through the other instrument at any desired rate of speed or slowness. They would come in on one instrument at the rate of forty words a minute, and we would grind them out of the other at the rate of twenty-five. Then were we not proud! Our copy used to be so clean and beautiful that we hung it up on exhibition, and our manager used to come and gaze at it silently with a puzzled expression. Then he would depart, shaking his head in a troubled sort of way. He could not understand it, neither could any of the other operators, for we used to drag off our impromptu automatic recorder and hide it when our toil was over. But the crash came when there was a big night's work—a Presidential vote, I think it was—and copy kept pouring in at the top rate of speed, until we fell an hour and a half or two hours behind. The newspapers sent in frantic complaints, an investigation was made, and our little scheme was discovered. We could not use it any more." It was this instrument that led to the invention of the phonograph.

Mr. Edison was once asked how large a percentage of what is popularly termed genius was in his estimation inborn genius, and how much hard work and application, or "grit and gumption." He replied, "Well, about 2 per cent is genius and the rest is hard work." He has a great objection to be called a discoverer. The majority of his inventions are the result of sheer hard work and lawful deduction. An illustration of this assertion of his, concerning the deliberative and foreseeing nature of invention, came up in a chat about the telephone and its present level of perfection. As is no doubt known, Mr. Edison added to the original Bell telephone one thing that it needed to make it thoroughly practicable. Bell and his associates invented and patented a receiver which answered its purpose exceedingly well; but it was left for Edison to invent and patent the carbon transmitter. He sold the right in the United States to the Western Union, and it will be remembered that the war between the two companies was amicably settled. "In England," said Edison, "we had fun. You see, neither the Bell people nor we could work satisfactorily without injuring one another. They infringed on my transmitter, and we infringed on their receiver; and there we were cutting each others' throats. Well, of course, this could not go on for ever, and consolidation had to come, although a second fight over the terms of this consolidation was bound to come. In a measure they had the whip hand of us; so I was not surprised to receive one day from our representative in England a telegram, the gist of which was that the Bell people wanted more than their share of the receipts in case of consolidation, and that our agent was at his wits' end what to do. I cabled back at once to the effect: 'Do not accept terms of consolidation. I will invent new receiver and send it over.' Then I set to work. I had found out before that electricity altered in some mysterious way the coefficients of friction in moving bodies, and I determined to turn this fact to account. In three weeks I had a receiver finished which worked even better than Bell's, and in less than no time afterward we had got six hundred of them made. With those we started off a body of men on a quick steamer, and an instructor went along, who, during the voyage, taught the men how to manipulate the new receivers, and how to make them if more should be required. The new receivers, immediately on their arrival in England, were attached to the instruments in all our stations, and this brought our opponents round. We consolidated on equal terms shortly afterward." This happened about the year 1887.

On the subject of incandescent electric lighting Mr. Edison himself says: "The electric light has caused me the greatest amount of study, and has required the most elaborate experiments, although I was never myself discouraged, or inclined to be hopeless of success. I cannot say the same for all my associates. And yet through all those years of experimenting and research I never once made a discovery. All my work was deductive, and the results I achieved were those of invention pure and simple. I would construct a theory and work on its lines until I found it untenable, then it would be discarded at once, and another theory evolved. This was the only possible way for me to work out the problem, for the conditions under which the incandescent light exists are peculiar and unsatisfactory for close investigation. Just consider this; we have an almost infinitesimal filament heated to a degree which it is difficult for us to comprehend, and it is in a vacuum, under conditions of which we are wholly ignorant. You cannot use your eyes to help you in the investigation, and you really know nothing of what is going on in that tiny bulb. I speak without exaggeration when I say that I have constructed three thousand different theories in connection with the electric light, each one of them reasonable and apparently likely to be true. Yet in two cases only did my experiments prove the truth of my theory. My chief difficulty was in constructing the carbon filament, the incandescence of which is the source of the light. Every quarter of the globe was ransacked by my agents, and all sorts of the queerest of materials were used, until finally the shred of bamboo now utilized by us was settled upon. Even now I am still at work nearly every day on the lamp, and quite recently I have devised a method of supplying sufficient current to fifteen lamps with one horse-power. Formerly ten lamps per horse-power was the extreme limit."

Mr. Edison's laboratory at Llewellyn Park, N. J., is a collection of buildings of brick and stone, erected at an enormous cost, filled with the finest tools, apparatus, and books the world could produce, and the whole is given up solely to instrumental research and constitutes the most remarkable, in fact the only enterprise of its scope and character in the world. According to a recent writer it contains samples of every substance in the world. The thousands of pigeonholes and drawers contain skins, feathers, and furs of the whole animal creation, bones and tusks of all sorts of creatures, minerals, barks, grasses, drugs, fruits, and gums in bewildering completeness. Some of the species are so rare that they are kept like diamonds, in little folded papers. The grotesque nature of some of the materials there collected prompted the inquiry, "How can you ever want such things as sharks' teeth or rhinoceros horn?" "Ah, that question shows that you don't know what queer things electricians use," replied our modern Virgil. "During the progress of the experiments with the incandescent electric light, for instance, nearly everything one can think of was tried as a primary material from which to form the delicate

* Abstracted from a paper read before the Rugby Engineering Society.

carbon filament whose incandescence is the source of light. Again, the delicate needle which, affixed to the underside of the vibrating diaphragm of the phonograph, indents the smooth revolving surface of the waxen cylinder, had to be formed of some material possessing peculiar properties of elasticity and rigidity, and so it goes with all the little details of electric appliances."

[Concluded from SUPPLEMENT No. 1525, page 24482.]

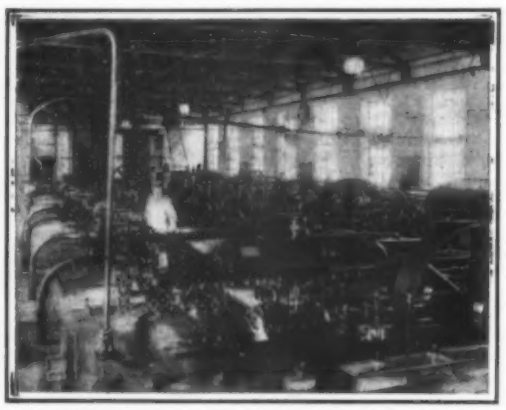
COMPLETION OF THE SIMPLON TUNNEL.—II.*

By CHARLES R. KING, C.E.

ENGINEERING IMPOSSIBILITIES OF RENEWING ATTACK FROM SWISS SIDE.

At this time the whole of the hydraulic works was already of an extensive and costly nature, and further amplification of the plant for continuing the work would have entailed grave additional expense in the total cost of the tunnel, and, also, a considerable period of time to make the installations. The power water has to be conveyed over three miles from the large reservoirs near Mörel to within a short distance of the turbines in a flume of rectangular section built of reinforced cement (Hennebique system) fitted with numerous air-valves and carried along the valley on piers of the same material even where the conduit crosses the main Goeschenen-Brig road; and then, a little beyond, the pipe line is carried over the Rhone River, as shown in the illustration.

The steam plant at Brig is sufficient to keep up the ventilating air-supply in case of an emergency, but since the latest installations of centrifugal pumps were made, there was very little margin of steam-power available for these. It is true that the whole of the auxiliary steam power might have been employed, for a time, to supplement the water power and so combat the hot water inflows, but then more pumps would have been necessary, and also a third high-pressure main for the centrifugal drainage pumps in the tunnel, as well as another large low-pressure pipe to convey cold water to all parts of the tunnel works where operations were in course. Further, all these pipes would have had to be insulated by means of the best medium which has yet been found practicable in the tunnel, that is, broken charcoal packed in an outer casing pipe of sheet iron. Then again other drawbacks would have occurred, for, with the greater volume of cold water for refrigeration and for power then to be forced into the tunnel, larger or additional pipes (also jacketed) would have been required for the drainage discharge from the headings. But, considering that already the space occupied by the pipes in service allowed so little clearance room on each side of the heading spoil-trucks as to impede and even endanger the safety of the various maneuvers (in consequence of which operations a large proportion of the lives lost are attributable), the whole scheme would have become impracticable, and particularly so with the system adopted of driving the headings in counter-ramps. By this latter expedient of driving the tunnel the heavy pumping work necessary on the return grade (25 per thousand) could only be effected with the portable plant and discharge pipe which occupied, as before explained, nearly the whole area of the drift. From this it will be clear that the distance of the heading from the source of the power, the reverse gradient falling away from Brig, and the great length of heated tunnel (which tended gradually to increase in temperature as more hot springs were tapped) all contributed to render further advance quite impracticable.



AIR COMPRESSORS AT BRIG, THE SWISS END OF THE TUNNEL.

The chances of success at the southern side of the boring were much greater, for there the whole grade of the tunnel throughout (of 7 per 1,000) rendered drainage pumping unnecessary, and the lesser temperature of the rock, which prevailed up to September 6 last in the Italian headings, enabled the refrigerating water to be brought to the front without the difficulty and need for voluminous non-conducting jackets for the pipe lines, such as were obligatory at the north end of the tunnel for two years past, and, more recently, in the Italian workings.

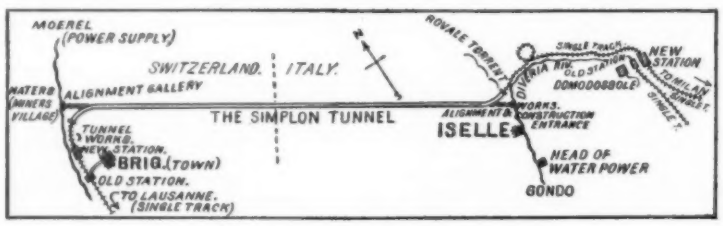
CROSS SECTION OF HEADING.

EXPEDIENT TO AVOID LONG-DISTANCE PUMPING IN HEADINGS.

The system of working which had been adopted previous to the flooding of the headings at the Swiss side will be apparent from the sectional sketch shown herewith. When arrived with the extended or false grading at the level of the crown, enlargement to the normal section had to proceed downward, and subsequently both upward and downward until the bottom of the constructional grading was reached. The crown was completed first, and the downward excavation proceeded along one side of the tunnel, as in the "Belgian" system, in which the advance drift always follows close to the eventual crown.

CHANGED METHODS OF ENLARGEMENT IN CHANGED SITUATIONS.

Changes have also been made in the methods of working, differing from the regular "Simplon tunnel" system, these new methods having been called for by the great heat prevailing in the last three kilometers of the Swiss boring. Now, instead of enlarging at a number of different points by means of an upper gallery reached through shafts driven in the crown at various intervals, the excavation proceeds upward and outward to full section along a single given length, with the improved result that the free air has an easier access to the unenlarged section, as shown at the Swiss end, in the cross section. Previously, while working with shafts and an upper drift, as shown at the Italian end, it frequently happened that, from various causes, it was not possible to terminate the enlargement sections all in regular sequence, so that there would sometimes be an unfinished section that would occasionally block the passage of the air to some completed section farther ahead; while in the upper drifts the want of direct ventilation (without fans and pipes placed locally) rendered operations in the stifling heat impracticable from the slowness of the work when it was done thus, although this disadvantage was not until quite recently so pronounced at the Italian, or southern, side, where the regular Simplon system is still continued. The work of excavating the hard rock of the crown and striking upward with underswings from the sledge-hammers, as done in the new system, impresses one as being painfully slow work. The work, however, appears to proceed much more rapidly than when working horizontally in upper drifts.



COURSE TAKEN BY THE SIMPLON TUNNEL.

IMPROVED CONNECTIONS BETWEEN TWIN TUNNELS.

Another plan has now been followed in the boring of the transverse passages at the Swiss end when it had reached near to the summit of the tunnel. Instead of short passages with sharp angular connections into either of the tunnels, these passages were latterly made larger, so as to be practicable for construction trains pulled by steam locomotives, instead of being limited to the small compressed-air locomotives. This method is found to repay the extra length of the branch passages.

AN INCONVENIENCE OF DETAIL IN TWIN TUNNELS.

A certain disadvantage, which exists together with the overwhelming merits of twin tunnels for such a length and depth below the surface, may here be noted. It consists in the possible disturbance of the masonry lining in the main tunnel, by reason of the detonation of side mines in the enlargement areas of the parallel tunnel No. 2, and which are apparently liable to upset the balance of the stratifications, or else it is that the original pressure takes a different leaning as full excavation proceeds in No. 2. In fact, rebuilds have been obligatory at many points in the twin tunnels where both are completely excavated to full normal section along a length of about 500 meters (1,640 feet) for the crossing of trains in mid-tunnel until tunnel No. 2 is eventually completed throughout its full length. One rebuild occurs in a section 13 meters (42.64 feet) long (between kilometers 9.107 and 9.120) where the arched roofs are of concrete. Concrete bricks, it may be remarked, have been employed at the Swiss end to a considerable extent, and in many parts where the natural crown was thoroughly dry, for the sole reason that stone is less plentiful at the Swiss side than it is at Iselle, in Italy. In fact, about 56 per cent of the 9,561 meters (31,210 feet) of completed crown ring on the north side are of concrete bricks. At the Italian side concrete blocks have only been used principally for the main drain.

The inspection of masonry defects arising subsequent to construction is very close, Swiss government inspectors always being present; and, after ascertaining that the development of incipient faults has ceased, the defective work is cut out. In this way the walls, where slightly fissured in the sides of the rings at kilometers 8.915 to 8.920 in tunnel No. 2, have been renewed over a surface of 4½ square meters (48½ square feet), and similar fissures in No. 1 tunnel, 40 meters (131.2 feet) farther ahead, have also been marked out for renewal.

As compared with the immense value of twin tunnels for construction purposes, the slight inconveniences that have been remarked in practice are insufficient to weigh against the merits of the twin-tunnel system, which alone has permitted the accomplishment of an otherwise impossible task.

SOME NOTES ON THE LAST BORING WORK ON THE SWISS SIDE.

During the last part of the time of boring the tunnel the conditions of working in it at the north end were not too trying, since all the power for refrigeration was employed at the enlargement sections and the air was

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

BRANDT HYDRAULIC ROCK DRILLS.

STEAM TUNNEL LOCOMOTIVE.

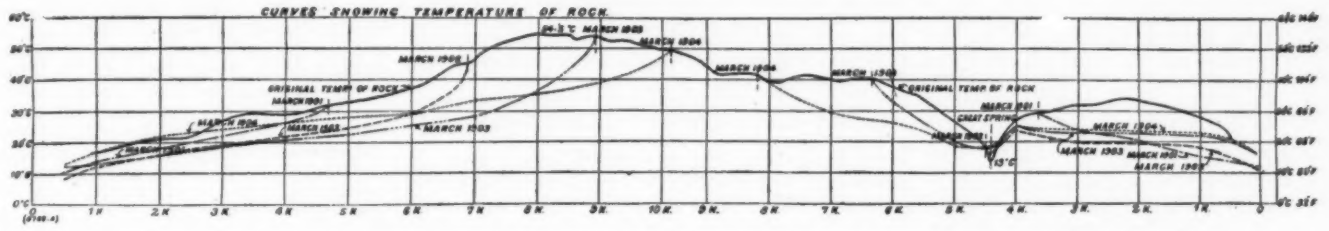
THE COMPLETION OF THE SIMPLON TUNNEL.

not vitiated by fumes from the headings as before, when three rock borers were employed in the main tunnel No. 1. These machines, in the last quarter term during which they were at work at the Swiss end, aggregated a service of 46 days, or of 362 hours each one, in boring a total of 1,941 holes aggregating a depth of 2,205 meters (7,332.4 feet), or about 11 holes of 1.13 meters (3.7 feet) in depth for each lift, of which a total of 176 were effected in employing 11,389 pounds of dynamite, resulting in an excavation of 199 lineal meters (652.72 lineal feet) with an average heading section of 6.1 square meters (65.65 square feet), or of 1,210 cubic meters (4,273 cubic feet).

The time employed for charging the holes and clearing the heading after each blast averaged 3 hours 34 minutes, or a total of 628 hours for the excavation previously mentioned. The tubular boring-cutters of the hydraulic rock drill were sharpened (softened, drawn, reset, and hardened) an aggregate of 14,060 times, the total aggregate consumption of their length (shortening) being 586 feet. The temper of these tubular cutters is such that when dropped (fresh from the forge) upon granite, the mineral "flies" like glass.

The hand work (perforation) in the same main tunnel, No. 1, did not amount to more than 58 cubic meters (2,048 cubic feet) in the period mentioned and this, together with about 10,114 cubic meters (357,165 cubic feet) excavated in the enlargement section, required as much as 17,204 pounds of dynamite for a total of 39,519 blast holes. This included the work in the cut-out or station in the middle of the tunnel. This branch in No. 2 has a length of about 500 meters (1,640 feet), and is now completely riveted throughout. It is of the same full normal section as tunnel No. 1. It will, as before suggested, allow the crossing of trains in the middle of the tunnel until No. 2 tunnel can be terminated some years later. The total of all forms of excavation in the last three months of boring was 11,324 cubic meters (361,438.78 cubic feet), and of this only 10.7 per cent were machine-bored. The daily consumption of dynamite was 585 pounds, or 10.4 pounds per cubic meter (0.29 pound per cubic foot) of machine perforation, and 1.71 pound per cubic meter (0.048 pound per cubic foot) of hand-excavation, the average consumption for the whole of the work being 2.55 pounds per cubic meter (0.072 pound per cubic foot) excavated. From the foregoing it is apparent that, together with the heat emanating from the rock and from the circulation of hot water in the tunnel, there was a considerable volume of air to be renewed to maintain sufficient aeration.

The Swiss ventilators, revolving at 356 R.P.M., drive the air into the No. 2 tunnel, which is closed at the Brig end, and, as all the intervening cross passages are closed, it does not enter into the main No. 1 tunnel excepting when it arrives at kilometer 10.104, where there is a short, straight air-passage 12 meters (39.36 feet) in length connecting the tunnels just before the iron water-gates are reached. This small drift starts at right angles from tunnel No. 2 and runs up a steep grade into tunnel No. 1. There are 52 transverse passages on the Swiss side, one of which was in the submerged section, while the rest, having a total aggregate length of 739½ meters (2,425½ feet), are now terminated throughout. The quantity of air driven through the tunnel at the north end averages in every 24 hours, and at an initial pressure of 233 millimeters (9.173 inches) of water, 2,359,580 cubic meters (83,326,208 cubic feet) as measured at the 8,830 kilometer point. Its temperature at the entry to the fans averaged (in the second quarter of the year) 15.02 deg. C. (59.03 deg. F.), but when arrived at the auxiliary ventilator (situated at kilometer 10.104) for driving it on beyond the last cross connection between the tunnels, this temperature was more than doubled (33 deg. C., or 91.4 deg. F.). When the water-gates were finally closed in May last, the auxiliary ventilation was suppressed, as the air then circulated right up to the gates without employment of secondary fans in the headings.



TEMPERATURE CURVES SHOWING INCREASED TEMPERATURES THROUGHOUT THE TUNNEL DUE TO ITS GREAT DEPTH.

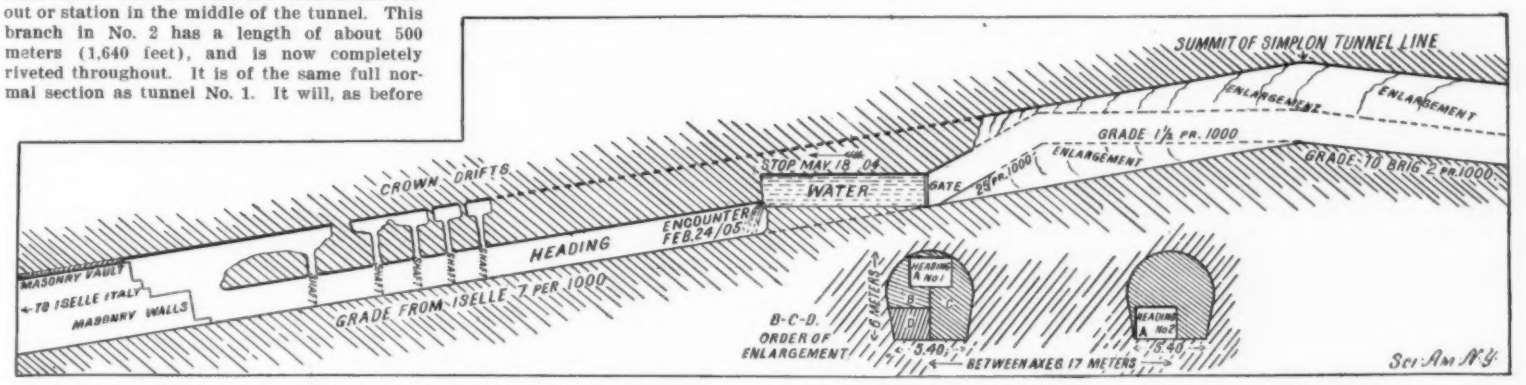
DETAILS OF IRON SAFETY GATES IN THE SWISS HEADINGS.

These gates are built of channel sections riveted diagonally—× form—across girders of I section, and then covered with boiler plates. They weigh about 8 tons each and are designed to resist a hydraulic pressure of 147 pounds per square inch. Each gate is suspended from the channel-iron gate-frames by four heavy cast-iron reinforced hinges, all at the same edge of the gate and are bolted to the inside face, i. e., next to the water. The clear opening in the frames is 1.3 meters (4.26 feet) wide by 1.9 meters (6.23 feet) high. The gate passages are built of masonry for the walls and crown, and of concrete for the sill; and through the 6-meter (19.68 feet) walls on either side pass the following conduits.

THE GREAT PUMPING PLANT IN THE SWISS HEADINGS.

The pipes in this part of the tunnel consist of a cast-iron discharge pipe of 400 millimeters (15.74 inches) diameter, which formerly connected to the pumps in the flooded headings; a low-pressure cold-water supply pipe 254 millimeters (9.999 inches) diameter; and a 253-millimeter (9.96-inch) drain pipe carrying the return grade water from gate No. 1, through the cross passage No. 52, back into the lower level (40 centimeters, or 15¾ inches below) of tunnel No. 2, where it is then discharged into a well, and from which it is again pumped out, through a suction pipe, 300 millimeters (11.8111 inches) diameter, by two centrifugal pumps located farther back in a niche in tunnel No. 2 at kilometer 9.861. The main tunnel heading is also drained by a centrifugal stationed in a rearward passage at kilometer 9.680. All these pumps are direct-connected to turbine motors (Pelton wheels). The hydraulic pressure now available is 1,180 pounds per square inch, but during the last few months 440 pounds has sufficed for actual needs.

On the opposite side of the gate entrance are two weldless Mannesmann steel mains of 100 millimeters (3.937 inches) diameter, one formerly supplying power for the Brandt rock-drills and one for running the turbines of the centrifugal pumps in cross passage No. 52. The cut-off gate valves are numerous, in order to limit the extent of the drainage if an accident had occurred to the low-pressure pipes. The whole installation was left in place, so that when the critical moment arrived for the piercing of the last yard of intervening rock, the Swiss connections could be run through into the Italian heading to give all available assistance there.

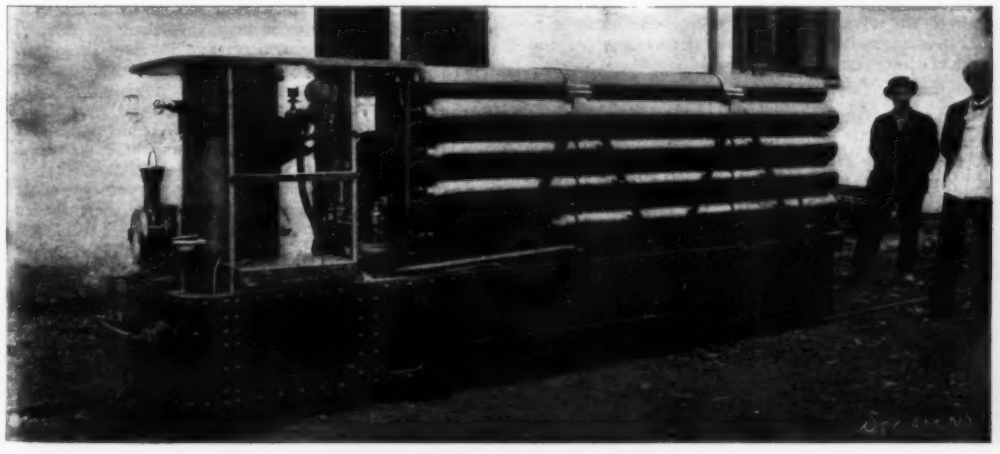


SECTION THROUGH THE SIMPLON TUNNEL AT SUMMIT, SHOWING METHOD OF RUNNING THE HEADINGS FROM THE ITALIAN SIDE IN ORDER TO DRAIN THE WATER WHICH HAD PREVENTED WORK FROM THE SWISS SIDE.

THE GREAT HEAT IN THE ABANDONED SWISS HEADINGS.

Before the completion of the boring, the entire end-face of the passage walls, as also the gates, were completely screened off with 4-inch planks serving as non-conductors of heat. The heat which passed these was none the less very considerable. Standing against the planks, one found himself in the hottest place in the whole tunnel, and one had the impression of some great furnace located on the other side. There was nothing otherwise to be remarked outside of the gate at kilometer 10.129 in tunnel No. 1; but the gate in tunnel No. 2 at kilometer 10.112 must have buckled, or else the frame yielded to the pressure, as the fit became so bad that the bursting through of water was distinctly audible behind the wooden barricade.

To save the gate from becoming still more badly damaged, it was necessary to allow the 400-millimeter drain to run off the confined water to relieve the pres-



COMPRESSED-AIR TUNNEL LOCOMOTIVE.

INTERIOR OF THE FIRST TUNNEL.

THE COMPLETION OF THE SIMPLON TUNNEL.

sure, and the flow of this water could be distinctly heard in the pipe close to the gate, while the heat emanating from the pipe at that point was palpable. At this part of the heading the cast-iron drain pipe was cleated with thick planks, tightly banded around it in octagonal form, but farther back, about 230 meters, the cast-iron pipe ceased and the drain was formed exclusively of wooden planks, this flume holding the water with scarcely any apparent drip.

DETAILS OF THE COURSE FOLLOWED BY THE HOT WATER.

The total length of the hot-water drainage pipes is 2,355 meters (7,724.4 feet), of which 342 meters (1,121.76 feet) are cast-iron pipe of 400 millimeters (15.74 inches) diameter; 365 meters (1,197.20 feet), of 350 mm. (13.77 in.) diameter; 555 meters (1,820 feet), of 300 mm. (11.81 inches) diameter; 436 meters (1,430 feet) of 250 millimeters (9.84 inches) diameter; and 65.7 meters (215.49 feet) of wooden pipe or flume of 400 millimeters diameter. This drain passes first along tunnel No. 2, and thence out into the main tunnel No. 1 by the cross passage No. 49, at kilometer 9.480, so avoiding the tunnel siding in No. 2 and yet presenting no obstruction to traffic from the branch passages by means of being carried underground, while the high-pressure mains at this point are carried clear overhead, above the cross-over passages, by means of chains suspended on the timber struts. From No. 1 the drain is carried back again into the parallel tunnel by cross passage No. 46, at kilometer 8.840, where it discharges into the great main drain of No. 2. This discharge of hot water—about 90 liters (23¾ gallons) per second at 37.5 deg. C. (99.5 deg. F.) temperature—was still undiminished in volume notwithstanding the large volume of water tapped at the Italian side. Flowing as it does through the same small tunnel, No. 2, by which all the power and cold-water mains, as also the free air, pass to the headings, it necessarily imparts much of its heat to the atmosphere (this being at the rate of 1,350 calories per second) and thus diminishes the efficiency of the refrigeration by 65 per cent and considerably aggravates the atmospheric conditions throughout all those sections where work is proceeding. Where the drainage water discharges into the Rhone River, it has a temperature of 26 deg. C. (78.8 deg. F.). The water accumulated behind the gates, estimated at 1,800 tons, had a temperature of 45.3 deg. C. (113.54 deg. F.) while that escaping through the leak in the gate of No. 2 tunnel was only 43.2 deg. C. (109.76 deg. F.), a difference of 2.1 deg. C. (3.78 deg. F.).

A BIG PLANT FOR COOLING THE AIR.

The refrigeration is effected by means of 10,420 meters (34,117.6 feet) of 253-millimeter (9.96-inch) pipe in connection with four refrigerating appliances of 71 heads and 11 big jet sprays disposed as follows: In tunnel No. 2, one 22-head apparatus at kilometer 8.860; two big jet sprays at kilometer 8.874; and one large jet with 31 spraying heads at kilometer 9.480. One of the types of sprays used is shown among our illustrations, the flashlight photograph depicting the spray bathing all the sides of the heading. In tunnel No. 1 a large apparatus with ten heads is located at kilometer 10.095. Farther back, at kilometer 9.850, is a conduit with sprays, and still farther back, two large jets at kilometer 9.500, besides two more each at kilometer 9.100 and 8.729. All these positions are of course in the neighborhood of rock that is greatly heated by the infiltrations. It is to be remarked that the plan is always followed of carrying away the hot water as quickly as possible to a point where it has not the same local inconvenience, although sooner or later before it escapes from the tunnel it is evident that the air must unavoidably become heated by it in the great length that it has to travel to get away, and notwithstanding the care that is taken to protect all the pipes both from hot and cold irradiations.

RADIATION OF HEAT THROUGHOUT THE TUNNEL.

Even the rock itself becomes heated by the discharge water in tunnel No. 2, and this to a remarkable degree at such a distance away in the rear as kilometer 5, where the rock temperature has reached 8 deg. to 10 deg. C. (46.4 to 50 deg. F.). In fact, it is found that as the refrigeration is diminished from any cause, the inherent heat of the rock returns once more to the excavated surface. For example, were the ventilation stopped entirely, there can be little doubt that the atmosphere of the tunnel would once more become equal in temperature to the original maximum of both rock and water.

The result obtained by the refrigerating plant employed has been as follows: In tunnel No. 2 (by which the air is driven up to the headings) the air temperature previous to refrigeration by water was as much as 32.5 deg. C. (90.5 deg. F.), but this was reduced to only 23.5 deg. C. (74.3 deg. F.) after the air had been passed through the water of the appliance at kilometer 8.860 and the big spray jet at kilometer 8.874, which was refrigeration in summer periods of 9 deg. C. (16.2 deg. F.) with spray water at 11 deg. C. (51.8 deg. F.) temperature. More recently, during the winter period, with water at an initial temperature of only 2.2 deg. C. (35.96 deg. F.), and at 6 deg. to 10 deg. C. (42.8 to 50 deg. F.) in the refrigerating appliances, the refrigerative effect produced remains the same as in the summer season, although using water of 5 deg. C. (9 deg. F.) lower initial temperature. In tunnel No. 1 (by which the air returns from the headings) the air temperature was 30 deg. C. (86 deg. F.) before refrigeration, and after passing through the large apparatus at kilometer 9.851, it was reduced to 24.5 deg. C. (76.1 deg. F.) or a lowered temperature of 5.5 deg. C. (9.9 deg. F.), and with the refrigerating water 4 degrees higher, that is, 15 deg C. (59 deg. F.). The large spray pulverizers reduced the temperature on an average by 3 deg. to 4 deg. C. (5.4 deg. to 7.2 deg. F.) and the large jets by 6 deg. C. (10.8 deg. F.).

POWER PLANTS AT THE SWISS SIDE.

The water for power driven into the tunnel at the Swiss side totaled in January 100 liters (26.4 gallons) per second, of which 23 liters (6 gallons) were furnished by the high-pressure plunger pumps in connection with the hydraulic accumulators seen in one of the illustrations representing the pump room at Brig (which resembles the identical installation at the Italian side), while 69 liters (18.21 gallons) per second were furnished by the high-lift centrifugal pumps for the refrigerating plant. This water in the power house has an average summer temperature of 8 deg. C. (46.4 deg. F.), while in the tunnel at kilometer 10.104 it attains 15 deg. C. (59 deg. F.) in summer and 10.5 deg. C. (50.9 deg. F.) in winter.

The refrigerating centrifugal pumps are run in series at 950 R. P. M. and work with a pressure of 370 pounds per square inch. The refrigeration conduit, besides supplying the apparatus already mentioned, furnishes power for four ejector pumps (large and small) and supplies water to six portable fountain heads located in the traversing galleries. For the transport of ice there are as many as eleven reservoir trucks of the normal construction gage—80 centimeters (31½ inches).

THE NECESSITY FOR INSULATING THE PIPE LINES.

The high-pressure pipe lines comprise 11,566 meters (37,936.48 feet) of 120 millimeters (4.724-inch) diameter, and 10,180 meters (33,390 feet) of 100 millimeters (3.937-inch) diameter. They are jacketed with charcoal, for even when the water leaves the pumps (or, as formerly, the rock drills) the discharge, after having expended its mechanical energy, is of value for cooling the advance workings; and it has been a feature in the Simplon tunnel that no possible advantage that could be obtained by the transport of hydraulic force was neglected. The 100-millimeter main pipe runs two turbines with centrifugal pumps, three ejector pumps, and supplies water to the steam locomotives.

WATER OUTFLOWS FROM TUNNEL.

The volume of water discharged from the tunnel (but not including that which is pumped in) was, in February, 200 liters (52.8 gallons) per second, 66 liters (17.42 gallons) per second of which volume are derived from infiltrations occurring along the northern incline of the tunnel. The total outflow into the Rhone River (by the side of the tail channel of the ventilator turbines) is approximately 238 liters (62.83 gallons) per second.

WATER POWER USED IN TUNNEL.

When the rock drills were last working on the Swiss side, the volume of water driven into the tunnel daily was 8,640 cubic meters (305,112 cubic feet), of which 6,300 cubic meters (222,478 cubic feet) were at that time employed for refrigerative purposes. Its temperature then averaged in the second quarter of the year, 7.8 deg. C. (46.04 deg. F.); its initial pressure averaged 1,456 pounds per square inch and diminished to 1,058 pounds per square inch at the rock drills.

COMPRESSED-AIR POWER TRANSMISSION.

The conduit for the compressed air is the only pipe line which is carried to the headings by tunnel No. 1, where the heated atmosphere causes no losses in its passage through that tunnel. This pipe has a total length of 10,417 meters (34,167 feet), of which 7,170 (23,517 feet) are of 50 millimeters (1.968-inch) diameter, and 3,247 meters (10,650 feet) of 30 millimeters (1.181-inch) diameter. A large engine boiler mounted upon a truck stands at the side of tunnel No. 1, at kilometer 9.640, for supplying the heat required in the hot-water reservoirs of the compressed-air locomotives. There are air valves on this main at kilometer 8.830 in tunnel No. 1 and at kilometer 9.640 in tunnel No. 2 for recharging the compressed-air locomotives. Compressed-air locomotives like that shown in one of our illustrations have been used at the Swiss end exclusively for the past two years, the heat of the tunnel there making the employment of horses impossible at the headings, as was still practicable at the Italian side until the great inflows of hot water there unfitted them for the already killing work. The exhaust from the cylinders of these locomotives aids, but almost imperceptibly, in the renewal of the air at the advance heading, where one of the machines has to switch the spoil trucks ready for the arrival of the steam locomotive.

ATMOSPHERIC CONDITIONS UNDER DIFFERENT OPERATIONS.

Leaving out of account the saturated atmosphere of the heading and its dense impregnation with sulphuric gases, the following records of the average air temperature in the last days of the work at the northern heading will give a general idea of the working conditions then prevailing:

During boring operations, 31.3 deg. C. (88.34 deg. F.); during mining and clearing operations, 31.8 deg. C. (89.24 deg. F.), with a maximum of 34.5 deg. C. (94.1 deg. F.). At the enlargement sections, 30½ deg. to 33 deg. C. (86.9 deg. to 91.4 deg. F.). At the masonry sections the crown attains 29 deg. to 32½ deg. C. (84.2 deg. to 90.5 deg. F.), and the walls 28 deg. to 30 deg. C. (82.4 deg. to 86 deg. F.) During the first part of February, in these constructional sections, the temperature varied between 29 deg. and 30 deg. C. (84.2 deg. and 86 deg. F.) at both sides of the Simplon tunnel.

THE WORK COMPLETED FROM THE ITALIAN SIDE.

From this end the work was followed regularly with an average advancement of about five meters per day. Apart from the important springs met at 4.5 kilometers from the Iselle entrance, the springs of water were small and did not seem to form any very great obstacle to the work. The 6th of September the head of the main southern gallery was 9,110 meters from the southern entrance at Iselle, and there were only 244 meters more to be tunneled in order to reach the abandoned north tunnel. At 10 A. M. there appeared in the calcareous schists being traversed a spring supplying 100 liters (26.41 gallons) per second, and whose temperature was 45 deg. C. (113 deg. F.). The temperature of the rock was 42.5 deg. C. (108.5 deg. F.) The work had to be stopped, and a transverse tunnel connecting the two tunnels was then constructed, so as to allow the hot water to flow out through the main tunnel by means of a lateral canal along the walls of this tunnel. The flow of this hot spring was then concentrated at a single point. In order to diminish the temperature, which stopped the men from working, the tunnel was cooled with jets of cold water. After the two parallel south tunnels had been connected at this point, a delay of three months sufficed to achieve the work of enlargement. When this was accomplished, the heading was pushed forward with all possible speed, with the result that the juncture of the south and north tunnels was finally accomplished on February 24, and the great volume of water accumulated in the headings of the north tunnels was tapped, and allowed to flow down through the south tunnel into the Diveria River. To accomplish this result has taken six and one-half years and the expenditure of $15,700,000. The best rate of advance of a single heading was 500 to 700 feet per month in dense granite rock.

OTHER DETAILS OF THE WORK.

The work was begun November 21, 1898. The main heading was pierced February 24, 1904. The time estimated for doing this was five years; that is, by November 28, 1903, allowing six months additional for the completion of tunnel No. 1, i. e., five and one-half years total, otherwise by May 21, 1904.

The price for the work was to be 69,500,000 francs ($13,000,000), and if the work was finished sooner, there was to be a premium of 5,000 francs paid for each day saved or a fine of 5,000 francs for each day of delay. The price named has been greatly exceeded, as the figures given above clearly show. At one time, owing to the unexpected difficulties with the heat, the contractors could not continue the ruinous expense of the work, and the ex-Jura-Simplon Railway Company was disinclined to agree to an indemnification for the contractors; but the Swiss Federation, which was shortly to take over the Jura-Simplon lines (now the Bundesbahnen, a state railway system) agreed to the increased expenses on national grounds.

The contractors are known as Brandt, Brandau & Co., of Hamburg and Winterthur.

Herr Brandt is no longer alive. The principals of this firm are now Messrs. N. Brandau, of Hamburg, and Locher, of Zurich, the first directing the works at Iselle (Italy) and the other at Brig (Switzerland). Both men are of fine physique, but the terrific anxieties of the enterprise have had a marked effect on both. A third (silent) partner is Sulzer, of Winterthur. Messrs. Sulzer Brothers furnished the greater part of the machinery required at both ends of the tunnel, such as four-stage high-lift centrifugal pumps and hydraulic turbines at the power stations; and centrifugal pumps driven by Pelton wheels in the swamped parts of the tunnels; the 12¼-foot fans, which are supplied in duplicate at both ends of the tunnel, and which will answer all requirements for the eventual working of the tunnel when open for traffic; the Brandt hydraulic rock drills, which they have recently improved in detail, greatly increasing its general efficiency; and a quantity of very handy hydraulic ejector-pumps for local drainage by suction have likewise been supplied by the same firm, which is, as need scarcely be repeated, considered as the foremost European maker of steam engines which alone can rival in economy the steam turbine.

The high-pressure hydraulic pumps which supply cold, filtered water to the accumulators (1,175 pounds per square inch) and thence to sixteen hydraulic rock-borers nominally working at both ends of the tunnels (four at each heading face) were also supplied by Sulzer Brothers; and the Pelton wheels, by which each pair of pumps is driven, were furnished by Escher, Wyss & Co., of Zurich, Switzerland.

All this plant is shown in one of the views, together with the air-compressors. The first machine, seen in the foreground, was built by the Ingersoll Rock Drill Company, of New York (capacity 3 cubic meters of free air per minute) and a second machine alongside (not visible) is by the Maschinenfabrik Burckhardt, of Basel, Switzerland, having a capacity of two cubic meters of free air per minute. Both machines compress air into a reservoir (tubular battery type) erected on the spot according to the processes belonging to the Mannesmann Tube Works, of Remschied, Germany. This latter firm has supplied about twenty-five miles of weldless steel high-pressure water mains that are now in use at both sides of the tunnel.

The low-pressure mains and the 10,000 feet of penstock pipes (of wrought iron, riveted), which convey the power water from the head intake on the Diveria (near Gondo) were supplied by J. J. Rieter & Co., of Winterthur.

The two 200-horse-power hydraulic turbines driving the large ventilating fans were supplied by Messrs. Sulzer. The same firm also supplied the two-stage auxiliary ventilators used in the tunnel headings.

Steam engines kept in reserve in case of failure of water power were furnished by Wolff, of Magdeburg-Buckau.

The steam locomotives were furnished by the Schweizerische Lokomotiv-fabrik, of Winterthur, which firm also supplied the compressed-air locomotives now used exclusively at both sides for work in the advanced headings.

The boring of the tunnel resulted in some interesting data regarding the increase of temperature with depth. We give herewith some temperature curves made at different periods, and a description of the same, from London Engineering. The difficulties of ventilation were intensified owing to the height of mountain over the tunnel; and, in view of the important question in physics associated with the increase of temperature per unit of depth from the earth's surface, the data in connection with temperatures in the Simplon tunnel become of great interest. These data were taken in the most systematic way. But before dealing with this interesting subject, a word may be said as to ventilation. We have mentioned already that the parallel heading No. 2 was utilized for ventilation in conjunction with cross-galleries, the air supply passing up the main tunnel, and the exhaust through the gallery No. 2. The air-supply from the Brig end equaled 33.9 cubic meters (1,197 cubic feet) per second, and from the Iselle portal 27.3 cubic meters (964 cubic feet) per second. A further interesting feature was the method of supplying cool air near the face when it was some distance in advance of one of the cross galleries. This was accomplished by having a special light sheet-iron pipe carried immediately below the roof of the heading. (See cross section, page 24452.) At intervals there was formed a connection between the hydraulic pressure main placed on the floor of the heading to project into the pipe a jet of air. As the hydraulic power water had a pressure at the face of 72 to 78 atmospheres, this jet induced through the pipe a strong current, which was conducted right up to the face. The water was collected in siphons in the bottom of the air-main at intervals, and there drained off. This proved a most satisfactory method of ventilation between the last cross-gallery and the face.

The effectiveness of ventilation slightly affects the assumptions which may be drawn from the temperature data taken, so far as it reflects on the question of increase of temperature per unit of depth from the earth's crust. A series of holes were made into the side walls to a depth of 1.5 meter (about 5 feet) at distances of 1,000 meters, as the work of boring proceeded, and into each hole was introduced a thermometer, from which observations were taken periodically, showing the ranges in temperatures. The full-line curve is plotted from the thermometrical readings taken immediately the 1½-meter borehole was driven into the side, close up to the face; and thus, as there was a minimum of influence due to artificial ventilation in the workings, the readings represent approximately the temperature due to the superincumbent rock; some allowance has been made for slight ventilation influence in plotting the curve. It will be observed that for the maximum depth, 7,005 feet—far greater than any depth previously attained—the maximum temperature of the rock was found to be 54.5 deg. C. (130 deg. F.). In the course of a paper to the Royal Society on this subject, Mr. Francis Fox, one of England's leading experts on tunnel ventilation, described the investigations he had made as to the increase in temperature due to the height above the tunnel. From elaborate data collected by the engineers, he chose at random the readings in March of the four years 1901-4, to show the rapid cooling of the rocks due to the boring of the tunnel. In March, 1901, for instance, when the tunnel had advanced from Brig for 4,693 meters (nearly three miles), the readings from the face toward the portal showed a considerable decrease. This is shown by a comparison of the thick line with the single dot-and-dash line. In March, 1902, the distance driven was 6,884 meters (4¼ miles), and there was a greater decrease, the temperatures then read at the thermometrical stations—1,000 meters apart—being recorded by the line of dashes. In March, 1903, when the tunnel had been advanced 8,930 meters (5½ miles), the thermometers gave readings as recorded in the three-dot-and-dash line, while the dotted line represents the readings in March, 1904, when the tunnel had been advanced 10,140 meters (6¼ miles) from Brig.

At the southern side of the Alps—that to the right of the diagram—the temperature rise corresponded approximately to the increasing altitude of the mountains up to the point 2,200 meters (1 1-3 miles) from the portal. There was then a diminution, culminating at 4,400 meters (2¾ miles), where a great spring of cold water was tapped, yielding 10,560 gallons per minute. At first the water issued at a high pressure, estimated at 600 pounds per square inch, but it gradually decreased. The temperature fell, the ultimate minimum being 13 deg. C. (55.4 deg. F.). From this point the temperature, first ascertained at 1,000-meter stations, again rose, coinciding with the temperature in the northern part of the tunnel for similar heights. Mr. Fox, in his paper, eliminated the effect of the great spring and the estimated influence of such disturbing factors as the inclination of the strata—where horizontal or vertical, and whether synclinal or anticlinal—and took also into consideration the temperature which was to be assumed as existing near to the surface.

In Sweden the government is attempting to favor the use of peat on railways, and has instructed the Board of State Railways to utilize it wherever possible without incurring loss.

CHICAGO'S UNDERGROUND FREIGHT TRAFFIC.*

By GEORGE E. WALSH.

WHILE New York has been busy devising ways and means to accommodate its enormous traveling public underground, Chicago has been quietly tunneling under its streets to build railroads that will relieve the freight traffic congestion of its chief surface thoroughfares. With the two systems nearing completion almost simultaneously, the relative value of the two systems of underground transit may receive a test that will ultimately settle some disputed points in municipal growth and expansion. While Chicago has committed itself to the underground freight traffic system, it has not entirely decided that it will never need underground railroads for the accommodation of passengers. Indeed, in the contract for building the underground freight tunnel, the city protected itself by specifying that at no point should the top of the tunnel come nearer than 26½ feet to the street surface. This part of the contract was made for the specific purpose of making provision for a tunnel subway similar to the one nearing completion in New York. There is sufficient room between the street surface and the freight subway to build a tunnel for passenger trains.

Chicago, owing to its topographical formation, found its freight traffic congested more than its passenger. New York's problem was one that concerned the handling and distribution of enormous crowds of people, which traveled continuously along a narrow longitudinal line and not laterally in all directions. With no less than twenty-five trunk lines of railroads running into the city, Chicago's freight tonnage traffic is enormous, and this is all located within a comparatively small territory—not more than a mile and a half square. Within this district teamsters' trucks constantly block the way, and cause such congestion of traffic that business is often paralyzed for hours at a time. New York's chief thoroughfares are congested enough, and in time some relief must be obtained; but Chicago had the problem of solving the question thrown upon her so that action had to be taken at once.

It was this difference in conditions of the two cities which decided New York to place the traveling public underground, and Chicago to put the freight traffic there. At first thought it seems the ideal method to give the streets and fresh air to the people, and the underground burrows and tunnels to the freight; but it is manifestly impossible to secure rapid transit in city streets and avenues. The only alternatives are elevated structures or tunnels.

The freight congestion of city streets is one of the problems of municipal development that seriously confront all towns of rapid and steady growth. The disappearance of the horse as a dray animal in the city, and the substitution of steam or electric trucks and wagons, would reduce the street congestion nearly one-half, and writers have constantly promised such ideal conditions in the near future; but in New York more has been gained through the regulation of the traffic, the occasional widening of certain streets, and the attempt to distribute the traffic along different thoroughfares. The tendency to follow certain favorite routes has always made prominent streets and avenues crowded to their full capacity, and it has only been by wise improvements and strict regulations that a part of this has been gradually deflected to less used streets and avenues.

In Chicago this was impossible in the congested districts down town. The freight traffic of this part of the city has been increasing so rapidly in the last few years that it threatened to cause trouble. The problem for the city to solve was keenly felt, and the city authorities were at a loss what to do. It was impossible to change the termini of the trunk railroad lines, and with the city's constant growth the freight traffic promised to double within every decade.

The tunnels of the Illinois Tunnel Company have been designed to handle nearly, or quite all, of this freight traffic which centers around the loop in the great business district, carrying not only all the freight which comes in by trains and must be distributed throughout the city, but likewise the enormous quantities of coal, building materials, and ashes and garbage from the giant office buildings. It is roughly estimated that nearly half a million tons of freight, coal, and ashes must be handled every week within this narrow district. To move this enormous amount 30,000 to 40,000 horses would be required, and the work would have to go on continuously every day in the week. The removal of this number of dray animals and carts from the streets of Chicago would afford a relief to the congestion of the streets that would immediately improve real estate value in the whole region.

This is the ambition of the present supporters of the underground freight tunnel. The work has been carried on somewhat quietly, and the completion of the tunnels this year will mark revolutionizing changes that will make the business section of Chicago vastly superior to anything in the past. All the coal used in the great business houses will be carried through the tunnel, and also all the ashes, garbage, waste, and old newspapers. From a sanitary point of view this change will be of inestimable value. The coal dust and ashes that constantly float in the air to be breathed in by the lungs must be responsible for many throat and respiratory troubles that cannot be cured without the removal of the irritating cause. The streets can be kept cleaner at less expense, and the danger from infectious disorders will be greatly minimized. The garbage, even when removed every day through the streets, always leaves a taint in the atmosphere which is certainly offensive to the senses if not actually injurious to the health. Another point that is worth considering is the actual saving to the city cleaning and street repair departments. The wear and tear on the street pavements by the continuous line of rumbling teamsters' carts have been very costly, and the street department is called upon to spend thousands of dollars every year to keep the pavements in fair condition. By removing the traffic from the streets, the tunnel company indirectly saves the city large sums of money.

The question of utilizing the underground freight tunnel for transporting the mails, and for accommodating the telephone and electric light wires, has also been adequately solved, and the removal of all these underground where they can easily be reached by repair men will simplify another problem of municipal growth. The distribution of the mails from one station to another by underground trains will not only relieve the streets of a large traffic, but will increase the prompt delivery of letters. The companies operating the telephone, telegraph, and electric light wires constantly disturb street conditions by the necessity of tearing up to repair lines. If the lines are laid in the tunnels, with proper facilities for reaching them at any point, the streets will no longer be needlessly torn up. This will represent a considerable item of saving to the companies, and will relieve the public of a nuisance and inconvenience that must appeal to all.

The new freight subway will be in partial operation before the close of the present year, and contracts have already been made to handle coal, ashes, and other freight at less than the minimum charges made by teamsters. By the first of the year the tunnels will be so far completed that the company will be in a position to handle 50,000 tons of freight a day, and by the end of another year, with the extensions projected, the total annual amount of freight that can be carried through the subway will approximate twenty-five million tons. Even this amount must soon be increased in order to keep pace with the rapidly-expanding conditions of busy Chicago.

The tunnels form a loop around the business section of Chicago, tapping each of the six freight depots where nearly all the freight tonnage of the trunk lines is received and distributed, and then spreading out to different portions of the city where freight traffic is most likely to go. There are completed about twenty miles of the subway, but eventually this will extend to include some fifty or sixty miles. As the city grows, and the freight traffic increases, provision will be made for extending the routes indefinitely. A comprehensive plan has been drawn up for present and future needs, and Chicago will as a result have her freight traffic provided for as no other city. Whether her traveling public will receive equally good facilities and accommodations in the future depends upon a number of other problems not yet solved.

The freight tunnels are of two distinct types—trunk tunnels and lateral conduits. The former follow the main routes of freight traffic, and the latter run out to the less important parts of the city. These in time will reach the suburbs and end in small conduits adapted only to accommodating telephone and other wires. The freight-carrying tunnels are built on a firm foundation of solid concrete, and are roofed over with the same material. They are made wide enough to permit trains to run in opposite directions, with accommodations on the sides for wires and cables. The trunk tunnels are 12½ feet high and 11 feet 2½ inches wide. This inside measurement is sufficient for all purposes demanded. The cars and engines to traverse the tunnels are of special design and pattern. The box freight cars are 4 feet wide, and stand 63 inches above the rail. This gives an inside measurement large enough to answer all purposes, for each car is 10½ feet long, with a weight capacity of 30,000 pounds. They are of iron and steel construction, with double trucks, and eight wheels. They are what is known as combination cars, which can be used either as a flat type or box car. Although of narrow size, they are built to accommodate almost any kind of freight, with doors wide enough to pass anything through that the ordinary type of railroad box car can receive.

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*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT

TRANSPARENT IRON FILMS.—It is easy to obtain transparent iron films by the ionoplastic method, in which the iron is deposited by cathode disintegration, but in attempting to measure the thickness of such films serious difficulties are encountered. The method of iodization, though applicable to silver and copper, does not work well with iron, and the conversion of the iron into oxide does not make exact measurements possible, owing to the inconstant composition of the oxide. An accurate method consists, according to L. Houllevigue, in dissolving the iron film in aqua regia and comparing the coloration of the solution with that of a standard solution of a known ferric salt. This, again, has the disadvantage of destroying the film whose thickness is to be measured. The author has, therefore, worked out a purely optical method, in which the error does not exceed 25 per cent. The method consists in measuring the transparency of the film in a Lummer-Brodhun photometer. Since the light transmitted by the film is grey it absorbs all rays equally, and the absorption is proportional to the thickness. The coefficient connecting the absorption and the thickness is determined by the colorimetric method mentioned above as involving the destruction of the film. Thus the author found for a film of 0.024 milligrammes per square centimeter a thickness of 39 $\mu\mu$ and a transparency of 0.114. With a film of 0.056 milligramme

per square centimeter, the thickness was 72 $\mu\mu$ and the transparency 0.0093; this transparency is, however, subject to a correction for reflection.—L. Houllevigue, Comptes Rendus, February 13, 1905.

COTTON GINS.*

By William Scott Taggart, M.I.Mech.E., Author of "Cotton Spinning."

The operation of stripping the fibers of cotton from the seeds was doubtless at first performed by hand. This must have been a very slow and tedious process, and no doubt prevented the extensive use of cotton for some considerable period after other fibers had become thoroughly established as articles of common use. A cotton-pod contains a large number of seeds, and each seed is surrounded by innumerable fibers growing from its skin or outer covering. The detachment of the

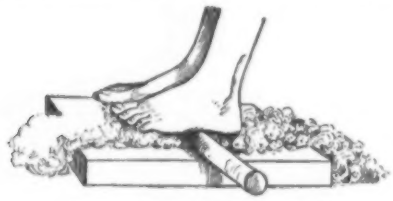


Fig. 1.—FOOT-ROLLER GIN.

fibers from the seed presents a problem which had to be solved before cotton could be used to any extent for textile purposes.

The earliest gin of which we have any record is the one known as the foot-roller gin. It consists essentially of a slab of stone or wood, and a roller. The cotton from the plant was placed on the slab, Fig. 1, and the roller pressed to and fro by means of the feet of the attendant. This action squeezed the seeds away from the fibers; and by this very crude method cotton was obtained which could be spun and woven into excellent materials. In the outlying districts of India large quantities of cotton, for local use, are still ginned by this primitive method, the production being from four to six pounds of clean cotton per day from each laborer.

The next advance was made by the introduction of the Churka gin. The same principle was used as in the foot-roller gin. Two rollers were supported in a framework, the top small one, of iron, being revolved at a higher speed than the large lower one. The fibers of cotton were carried through between the rollers, and the seeds left behind. Six to ten pounds of clean cotton could be obtained in this way per day. Large numbers of these machines are still used to-day in India and China, by villagers in out-of-the-way districts.

When cotton came to be used on a large scale in other countries than the East, the necessity for large productions to meet the demands gave rise to rapid developments in the cotton gin. Progress came from the side of those who wanted the cotton rather than from the growers; so that gins, as we know them to-day, date from the rise of the cotton industry in England and America.

Among many attempts made, the machine invented by Macarthy has stood the test of time; and at the present moment the greater part of the cotton crop of the world, outside America, is ginned by machines known by his name.

A section of the Macarthy gin is given in Fig. 3. A leather-covered roller, *A*, revolves as shown. Pressing against the roller is a steel blade, *B*, with a knife edge; springs, *C*, keep the blade pressed uniformly against

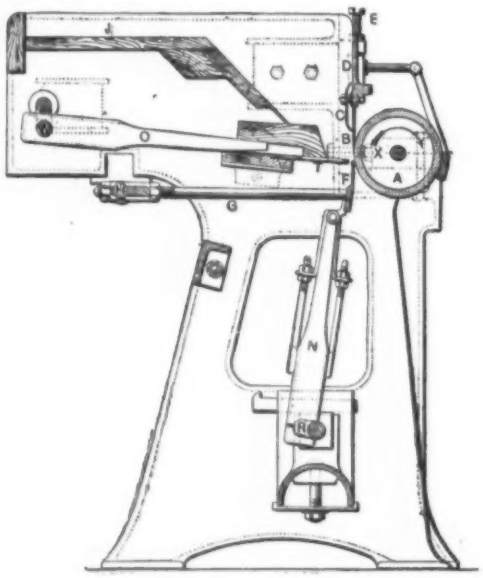


Fig. 3.—SECTION OF SINGLE MACARTHY COTTON GIN.

the full length of the roller. The seed cotton is fed along the table and into the hopper receptacle. The fibers come into contact with the rough surface of the leather roller, and are rapidly drawn between the steel knife and the roller, the seeds being left sticking to the edge of the blade. A vertical moving blunt blade of steel, *F*, is given an upward and downward motion by the crank, *R*, and the blade, *F*, is guided in the right direction by the radial arm, *G*, to which it is attached. The action of *F* is to give a very rapid series of taps to the seeds adhering to the doctor knife, *B*, and to so cause them to fall away through the grid, *T*, on to the floor. To give some idea of the speeds at which the machine works, it may be mentioned that the leather roller runs at 150 R.P.M., and the beater knife, *F*, strikes the seeds at the rate of 800 R.P.M. The production of the machine is over 50 pounds of clean cotton per hour.

A double form of the Macarthy gin is made, whereby a better balancing of moving parts is obtained, as well as a greatly increased production with smaller speeds. The single machine is always used for good long-stapled cotton such as Egyptian, Sea Island, etc.; while the double action gin is chiefly used for Indian woolly seed cottons.

We now come to another type of machine called the saw-gin. The advent of this machine is often said to mark the advent of America's commercial progress. Eli Whitney was the inventor, and his first machine was brought out in 1791. Previous to this year only very small quantities of cotton came to England from America, and that which came was always long-stapled Sea Island. Uplands cotton was practically unknown before the days of the saw-gin. The short fibers were so difficult to detach from the seeds, that only about a pound of cleaned cotton could be obtained per day from an operator. The Churka gin was used in America before the saw-gin was invented, but only the long-stapled Sea Island cotton could be cleaned on it.

To illustrate the importance of the saw-gin, it may be remarked that eight bags of cotton arrived in Liverpool in 1784, on board an American vessel, and were seized by the custom house authorities, because it was not credited that the fiber was American cotton. In 1787, 108 bags were imported, all Sea Island. Two years after the saw-gin was started the cotton crop of America rose to 5,000,000 pounds, and has grown enormously since. Uplands cotton in 1791 required two operators to produce two pounds of clean cotton per day; while at present two men, in charge of six ma-

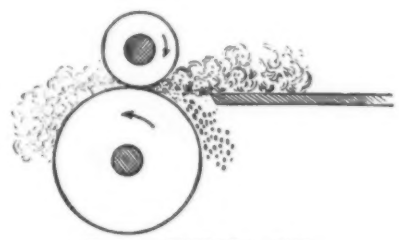


Fig. 2.—CHURKA GIN.

chines, can produce 24,000 pounds of clean cotton per day.

It is unnecessary to trace the development of the saw-gin since Whitney introduced it. It will be sufficient for the present purpose to give two sketches of it. In the first one, Fig. 4, two rows of saws are shown. Between each pair of saws is passed a plate or bar, *C*, the space between bar and saw being sufficient to allow fibers of cotton, but not seeds, to pass. The seed cotton is thrown into the hopper, *A*, and the saw teeth, revolving at a high speed, carry it round and tear the fibers from the seeds, leaving the latter behind to fall down through the grid, *E*. The brush, *D*, sweeps the cleaned cotton from the saw teeth and sends it along in the direction of the arrow at *J*. The bars, *C*, get choked with seeds at times, and when this happens the attendant presses the foot lever and lifts the bars clear of the saws, and so enables them to be easily cleaned.

A more modern form of saw-gin is illustrated in Fig. 5. The seed cotton has been considerably opened out before being brought to the gin by a machine called a seed cotton opener, which will open as much as a ton of seed cotton per hour. This opened-up seed cotton is dropped on to a traveling lattice, *A*, and is carried forward under a picker roller, *B*, which throws the cotton into a hopper, *D*, and so into what is called the gin breast. Here the cotton comes into contact with the revolving saws, *F*, between which are fixed the bars, *G*. (A side view of the arrangement of the saws and the bars is shown at the right of Fig. 5.) The fibers of cotton are torn from the seeds in passing through the bars, and the cleaned cotton is passed along the passage, *J*, being sometimes assisted by a draft from the drum, *K*. The fibers are carried round between the drum; *K*, and a roller, *L*, and from this point are delivered into some receptacle for making into a bale.

Students in England have only the cleaned cotton to deal with; but all practical men in responsible positions realize that the ginning operation is a very important one from several points of view. Badly ginned cotton means very dirty cotton; the skins of the seeds are torn off and broken up, and are difficult to remove in the subsequent processes in the cotton mills, thus entailing additional expense and care. The fibers of cotton are also damaged and weakened, so that the resulting yarn is of an inferior quality. Quality is of vital necessity in the textile trade, so that ginning is a factor to be seriously considered. The saw-gin is clearly a machine for giving a large output at a minimum cost, but it is equally clear that quality is sacrificed to obtain this. The long-stapled cottons are not ginned on this machine; and, strange to say, the greater proportion of the shortest and worst cottons are not cleaned on the saw-gin. These cottons almost invariably pass through the Macarthy gin. This latter gin, however, will produce only 1,000 pounds of clean cotton per day, while a saw-gin will produce 4,000 pounds per day; so that it is only a question of time for the saw-gin to oust the Macarthy gin from the market. Sea Island cotton, and to a large extent Egyptian cotton,

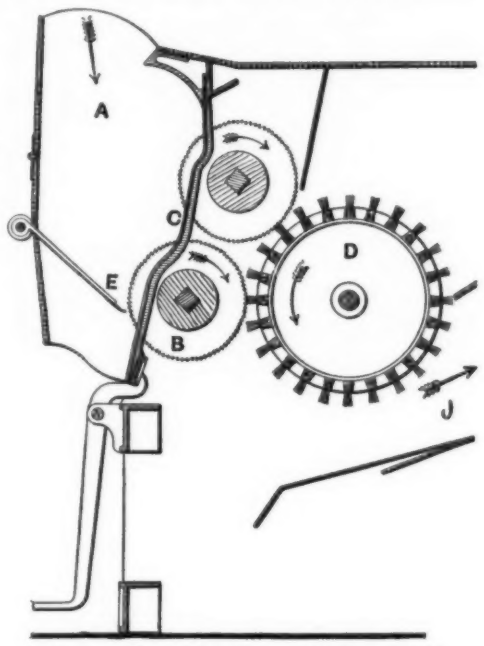


Fig. 4.—THE SAW GIN (OLDER FORM).

are luxuries; and all operations through which they pass are based on this fact. Present-day students had better prepare themselves for the future by thoroughly grasping this problem of ginning, for there is no doubt that there are distinct signs of competition and labor conditions compelling the adoption of the saw-gins in other than the American cotton-fields. In conclusion, it may be said that the amount of "lint" (as the cleaned cotton is termed) is usually about one-quarter of the seed cotton put in at the gin, so that for every ton of seed cotton gathered, only 600 pounds reaches the spinning mill.

THE STRENGTH OF TIMBER TREATED WITH PRESERVATIVES.

With the increasing use of timber, preserved in one way or another against decay and fire, it is important to determine the effect which the preserving process has upon the strength of the preserved timber. Many engineers believe that creosoted timber is more brittle and less capable of withstanding strains than the same timber before being treated with creosote. This is particularly true with bridge timbers and piling.

Actual tests are necessary to determine what relationship exists between the preservative process and the strength of the timber. Most of the tests hitherto made with preserved timber were made by comparing results of tests on treated sticks with results on untreated sticks. In many instances these turned out in favor of the untreated timber. The reason why such tests are unfair to the preservative is that in the process of preservation two factors enter: (1) The actual process of impregnation with a preserving substance, and (2) the preliminary processes of steam seasoning,

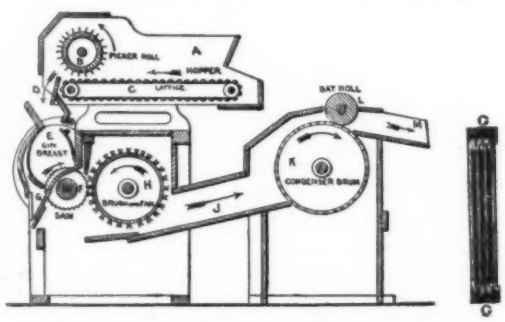


Fig. 5.—THE SAW GIN (MODERN FORM).

in the majority of treating plants in the United States. A piece of timber subsequently treated with creosote may be steamed to such an extent that the timber becomes exceedingly brittle. This, obviously, will be the fault of the steaming and not of the creosote.

Timber preservation divides itself broadly into three stages: First, the preliminary preparation; second, the actual preservative process; and, third, the treatment of timber following preservation. The final strength of the timber may be influenced materially by each of the stages.

The Bureau of Forestry has erected an extensive plant on the grounds of the St. Louis Exposition for carrying on a series of investigations of the methods for preserving timber, and of the influence various preservative processes have upon the strength of the tim-

* Technics.

ber. These investigations have been organized and outlined by Doctors von Schrenk and Hatt of the Bureau of Forestry.

This general plan was pursued during the last few months at the timber treating and testing station at St. Louis in accordance with the following outline:

(1) To determine the effect of the preliminary processes, such as steaming, on the mechanical properties of the timber.

(2) To determine the effect of preservatives on the strength of timber, eliminating the effect of the preliminary processes.

In order to determine the effect of these factors, the programme was divided into two parts—part 1, the effect of the preliminary process, and part 2, the effect of preservatives.

The effects of the preliminary process were determined only on loblolly pine. Both green and seasoned timber was used in determining the effect of preservatives. The preservative fluids investigated included only creosote and zinc chlorid.

In making comparative strength tests of treated and untreated timbers, it is necessary to eliminate as far as possible the variations due to the great differences in quality of individual pieces of wood. This was accomplished in this case by using 11-foot timbers cut at the same time from one forest site. In testing the influence of preliminary processes of seasoning, a 3-foot section was cut from one end of each timber and sawed up into test pieces, which furnished a basis of comparison between (1) the results of tests on these "control" pieces, and (2) the results on test pieces taken from the remaining 8-foot section after the latter had been subjected to the various preliminary seasoning processes in the treating cylinder.

In testing the effect of preservatives themselves the entire 11-foot timber was subjected to the preliminary seasoning processes, after which a 3-foot section was cut from the end of each timber. The 3-foot section thus having been subjected to the preliminary seasoning processes formed a basis of comparison with the remaining 8-foot section, which was treated with the preservatives. In this way the separate effects of the preliminary processes and the effects of the preservatives could be isolated and determined.

Because of an apprehension that defects of brittleness of treated timbers might not be evidenced by the ordinary tests under slowly applied loads, provision was made for both static tests and impact tests. The test pieces were subjected to crossbending strain, compression along the grain under both static and impact conditions, and under shearing parallel to the grain, and compression at right angles to the grain under static conditions. The data taken include the moisture conditions, specific gravity, and rate of growth. During the treating operations, records were kept of the temperature to which the timbers were subjected at all stages, the amount of water lost or gained, and of the amount of preservatives absorbed, as indicated by gross weight and subsequent chemical analyses of the test pieces.

Ordinarily the strength tests were made immediately after treatment in the cylinder. In order, however, to determine what weakness might be introduced by changes in the physical condition of the preservatives in the wood through lapse of time, a complete series has been set aside for subsequent operations. An additional set of test pieces has been loaded with different percentages of the strength, as exhibited under the ordinary tests, and this load allowed to act for long periods of time, the deflections being measured from day to day.

While this programme is not sufficiently advanced to allow the drawing of final conclusions, yet the preliminary results are fairly indicative of what may be expected. It is found that the steaming process weakens the resistance of the wood fiber to both static and impact loadings. It may be stated that this diminution of strength is very nearly in direct proportion to the length of time that any given steam pressure is applied. The diminution of strength was found to be 25 per cent after a pressure of 20 pounds was applied for ten hours to green loblolly pine, and 10 per cent when a pressure of 20 pounds was applied for four hours. This diminution of strength increased very rapidly when the pressure rose above 20 pounds, and amounted to about 25 per cent when a pressure of 50 pounds was applied for four hours.

It will be easily seen that when the conditions of time and pressure are made very severe, the conditions prevailing in a pulp mill industry will be approximated. Evidently it is well to avoid when possible the use of these preliminary steaming operations in the wood preserving industry.

With relation to the effect of preservatives themselves, the latter is distinct from the preliminary process. It may be said that the treatment with zinc chlorid does not seem to further reduce the strength of timber beyond the effect of the steaming process. This might have been expected when it is considered that the strength of the zinc chlorid solution ordinarily used does not exceed 2½ per cent. The strength of timber that had been treated with the 2½ per cent solution of zinc chlorid after having been steamed four hours at 20 pounds pressure was the same as that of timber which had been steamed without the subsequent application of zinc chlorid. The same statement may be made of timber treated with an 8½ per cent solution of zinc chlorid. It may be that subsequently the crystallization of the zinc chlorid will weaken the wood fiber. This remains to be determined.

The effect of the creosote appears to be the same as that of an equal amount of water in weakening the fiber. That is to say, the strength of creosoted timber is that of green timber. The difference is that while green timber gains strength upon seasoning, the creosote oil remains in the wood, and it appears from analysis of a pile 35 years old that the oil remains in a liquid condition. Consequently, comparison between seasoned timber and creosoted timber will always result to the disadvantage of the latter as far as its strength is concerned. In the case of creosoted wood, it also remains to determine what changes in the wood fiber take place through lapse of time in the presence of creosote oil.

It is expected that a bulletin will be issued upon the results of these investigations when the tests are completed. This bulletin will also contain the results of the investigations to determine the best methods of preserving wood so that the maximum impregnation may be obtained with the least expenditure of oil per cubic foot of timber.

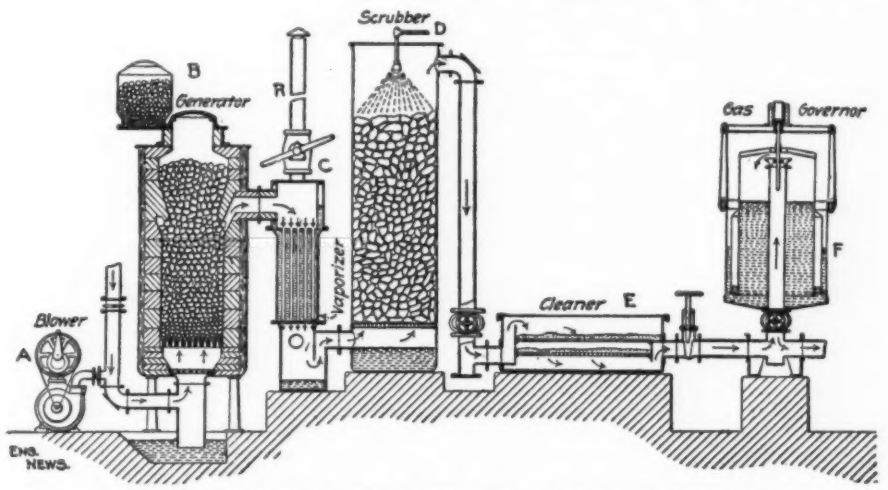
THE PINTSCH SUCTION GAS PRODUCER.*

By S. F. SAEGER.

THE development of the gas producer has brought out a new type of gas engine. Producer gas requires an engine with high compression, large inlet valves and governor control on the admission of both air and gas and the development of the gas producer industry was greatly retarded by the fact that these engine conditions were not seen and met.

The idea of making the suction of the gas engine piston generate its own gas had been advanced, and was, in fact, patented by C. Wiegand in 1884, but after investigation on the part of several interested firms the scheme was dropped and the patents allowed to lapse. Wiegand was, however, close to the solution of the problem and failed only because of an incomplete understanding of the requisite conditions.

In the fall of 1900 the firm of Julius Pintsch, of Berlin, Germany, put upon the market a practical suction gas producer which overcame all of Wiegand's difficulties. This producer was simple in construction and operation, required little attention and gave a brake horse-power-hour in small units on one pound of Belgian anthracite. Four years' practical experience with this plant brought many improvements and the construction of the present Pintsch suction gas plant is as follows: In the illustration *A* is a blower, furnishing draft for starting the fire and raising the heat in the generator to the proper temperature for the production of gas; *B*, a generator, equipped with a grate on which the coal is burned, a hopper, which allows charging during operation, a window valve for inspection of the fire, and fire doors for poking down; *C* is a vaporizer fitted with a small tubular boiler for the generation of steam and a relief pipe or chimney for use when the engine is not running; *D*, a scrubber consisting of a coke tower with a water spray for washing the gas; *E*, a cleaner containing wooden trays covered with wood shavings or saw-dust through which the gas is filtered, giving up the last of its dirt and dust; *F*, a governor or pressure equalizer for maintaining a steady pressure throughout the apparatus.



THE PINTSCH SUCTION GAS PRODUCER, 150-HORSE-POWER PLANT.

To operate the plant, a fire is lighted in the generator and a small amount of coal added, the blower being run until the fire is burning strongly with the relief valve, *R*, open. After ten to fifteen minutes' blowing, the fire is sufficiently hot to give off gas; the relief valve is then closed and the gas allowed to pass through the apparatus, the blower being kept running at slower speed until the gas burns freely at a test cock beside the engine. The engine is then started, the blower stopped, and the formation of gas becomes automatic, the suction stroke of the engine furnishing the draft through the fire. In ordinary practice, the fire is left burning over night with limited draft and only a few minutes' blowing is required to brighten up the fire in the morning. The generator should be kept full of coal and the fire kept clean and bright. Since the apparatus is always under a slight vacuum, the fire doors can be opened at any time for cleaning out the fire.

The vaporizer is built in three sections, the upper being simply a chamber connected with the relief pipe or chimney, the middle a small tubular boiler, and the base section acting as a cleaning-pot and water seal when the engine is not running. By the passage of the hot gases coming from the generator through the flues of the boiler, the gas is cooled and steam is generated which is passed back under the grate for the purpose later described. The cleaning-pot or bottom section collects the heaviest dust and dirt coming over with the gas. By the admission of water to the cleaning-pot on shutting down, the rest of the apparatus is water sealed and the gas therein kept intact for starting again.

The scrubber should never feel more than warm to the hand, otherwise steam will pass through it to the apparatus beyond, carrying with it a considerably greater percentage of dust, and the gas will not be cool when it reaches the engine. The gas must reach the engine cool or the charge taken in will be a charge of expanded and rarefied gas and will not carry sufficient energy.

In the cleaner the gas gives up the last of its dust and moisture and emerges cool, clean, and dry.

The gas governor (a Pintsch patent) used on these plants is of great value. The engine, on its charging stroke, instead of drawing entirely from the producer draws its charge in part from the governor and the governor-spring then compensates this by drawing in a fresh charge from the producer. The resulting suction on the producer when the governor is used is a steady draft through the apparatus instead of the intermittent pull which is made by the suction stroke of the piston. This steady suction gives a steady, even draft through the fire, which is an essential condition for the continuous formation of gas of a uniform quality, and as shown by actual test gives an added economy of 10 per cent. Another great benefit derived from the governor is the ability to run any number of engines from a single producer with certainty of operation and without any loss in economy, it being only necessary to attach a governor to the individual gas main leading to each engine.

The theory of the formation of the gas is that, by limiting the amount of air admitted to the fire, complete combustion of the coal is not permitted and the supply of oxygen being insufficient, carbon monoxide, CO, is formed instead of carbon dioxide, CO_2, while the steam formed in the vaporizer is led back under the grate and breaks up on striking the incandescent fuel, giving free hydrogen and carbon monoxide, the carbon monoxide and the hydrogen forming the power gas for the engine. The average gas with a good grade of anthracite should have a heat value of 130 to 140 B. T. U. per cubic foot and the constituents by volume should be as follows:

Carbon dioxide, CO_2	6 per cent
Carbon monoxide, CO	24 per cent
Hydrogen, H	15 per cent
Nitrogen, N	55 per cent
Hydro carbon, CH_4	trace
Oxygen, O	trace

Should the apparatus be of faulty design and more steam be admitted than the fire can break up, the effect will be a deadening of the fire and the diminution of the gas formed and in the end a complete shutting down. On the other hand, if an insufficient amount of steam is provided, the grates will burn out rapidly and the gas through a lack of hydrogen will be lacking in power. When anthracite is used the amount of water transformed should be from 0.8 to 1.2 times the weight of the coal burned.

The cleaner is often left off in the cheaper forms of apparatus, but an examination of the pipes on such a plant after a month's use will conclusively prove its necessity. Where water is an important factor the scrubber may be run hot and less water used, but it will be done at the expense of the cleaner, which will be forced to remove a greater percentage of dust, the same having been carried through to it by the non-condensed vapor; the sawdust and shavings would therefore require more frequent cleaning and renewal. Wherever necessary a cooling system can be installed and the water re-used after slight filtration.

As an example of the efficiency with which the gas in this apparatus is cleaned and dried an instance may be cited of an installation of Julius Pintsch at Heusy

* Abstract of a paper read before the Michigan Engineering Society. Our illustration is taken from Engineering News.

in Belgium, where a plant was run for an entire year without any cleaning whatsoever of either the engine or gas apparatus and the deposit of foreign matter found in the same at the end of the year was inappreciable. As for its reliability, a Pintsch producer and 50 horse-power Deutz engine was, in one instance, through necessity, run continuously night and day for nine months without a single stop for any cause whatsoever.

The superiority of the suction system over the old pressure type of gas producers has been conclusively demonstrated. There were originally many objections raised to the suction type and the idea of having the engine draw in its charge of gas, thereby making the draft for the fire and rendering the apparatus automatic, was considered impracticable. The point was raised that the gas being at less than atmospheric pressure would interfere with the satisfactory working of the engine. If it were impossible to regulate the admission of the air with the pressure of the gas this objection would hold true, but the same is taken care of by providing a separate air inlet on the engine which allows the formation of a suitable mixture in all cases.

The suction gas plant is simpler, cheaper, and requires less room than the pressure plants. It is more economical of fuel and requires less attention. It requires no separate steam boilers and there is no steam under pressure. It requires no large gas holders and there is no chance for gas to escape into any of the rooms of the building, as the whole apparatus is always under slightly less than atmospheric pressure and any leakage would be a leakage of air into the apparatus and not of gas out. A leakage sufficient to bring about a stoppage would have to be very large and could not occur in regular working except through some extraordinary accident.

The working of the Pintsch plant is practically automatic and the fire can be poked down and clinkers and ashes removed without causing any interruption to the production of the gas.

The air entering the producer below the grate is piped from outside the building so that any gas which might collect due to a sudden stoppage of the engine or a clogging of the pipes must escape through this inlet pipe to the outer air. Any irregularity is at once traceable by a series of gages which show the amount of vacuum at all times in the various parts of the installation.

It is a scientifically designed plant, thoroughly worked out and certain of operation, requires comparatively little room and is of such a character as to be a perfectly safe installation in office buildings, hotels, and the like, for which work it is in fact in wide use abroad, where Julius Pintsch has already installed over 2,000 plants ranging from 4 to 2,000 brake horse-power.

Julius Pintsch has built producers in single units up to 2,000 horse-power on the same lines as the smaller plants. These plants are operating with perfect success and consume only about ¾ pound of coal per brake horse-power per hour, the consumption decreasing with the increasing size of the unit. While this type of apparatus here illustrated has been spoken of as only available for anthracite coal it is with slight alterations equally available for any fuel that has not a tar base.

The consumption with gas coke, clean gas coke being advisable because of its freedom from sulphur, is in the 50 horse-power size 1.07 pounds per brake horse-power per hour, and about the same with charcoal. With pea anthracite at $5 a ton, the fuel cost is ¼ cent per brake horse-power per hour.

To date, the use of bituminous coal is confined to large units. To successfully operate a gas engine the tar must be removed, which necessitates either an elaborate system of scrubbers and cleaners, or the combustion of the tar in the producer itself. Working on the latter principle Julius Pintsch now has in operation plants for both lignite and bituminous coal, and a plant of 400 brake horse-power is working admirably on bituminous coal with the very low consumption of 0.625 pound per brake horse-power per hour. With bituminous coal at $3 a ton this brings the cost per brake horse-power per hour down to less than 0.1 cent, which, barring water power and natural gas, may be said to be the cheapest form of power yet known.

THE JUST-HATMAKER PROCESS OF MANUFACTURING MILK POWDER.*

By the English Correspondent of SCIENTIFIC AMERICAN.

IN the issue of the SCIENTIFIC AMERICAN for July 19, 1902, we described the experiments and successful manufacture of separated milk powder as devised by Dr. Joseph H. Campbell, of Jersey City, N. J. Simultaneously with these experiments, investigations to achieve the drying of full-cream milk as well as of separated milk were being conducted by Messrs. Just and Hatmaker in France, with conspicuous success.

The obtaining of milk in dry form is a great desideratum, not only on account of saving in bulk and convenience of transit, but hygienically. As has been pointed out by William S. Magill, M.A., M.D., of the University of Paris, and formerly bacteriologist of New York University, and chief of the Research Department of the Carnegie Laboratory, New York, certain improvements in ordinary cows' milk are absolutely imperative before it can be administered to infants with perfect safety. He has conclusively shown that milk as it comes from the cow always contains a large number of germs, and that such milk offers a most favorable medium for the rapid development of these germs, while there is time for their full development in nearly all cases, before the milk is actually consumed. These germs in the milk not only live upon it, and thus impair its nutritive value, but, what is far more important, they leave in it all their wastes, which are poisonous and the most prolific cause of infant mortality.

Various efforts have been made to retard the development of these germs, and to reduce their number by refrigeration, pasteurization, and so-called sterilization, but with only a partial measure of success.

Messrs. Just and Hatmaker have solved the problem in their process by completely destroying the bacteria without in any way impairing any of the nutritive qualities of the milk.

The features of this process are its simplicity and its cheapness of operation. The product is obtained by the rapid evaporation of the water contained in the milk by the employment of a high temperature. The result is that all the solids of the milk are obtained in a dry, but otherwise unaltered condition, in light, flaky, form. These solids are soluble, odorless, light in color, completely sterile, and conservable. They have a perfectly natural and agreeable taste, and form a highly nitrogenous food-substance.

The success of the process consists in the rapidity with which it is carried out, and the high temperature employed, for if milk is dried slowly at a low temperature, the dry product undergoes serious transformations, is not rendered sterile, and has a disagreeable odor.

The apparatus is simple in design. There are two metal cylinders, measuring 60 inches in length, and each of 28 inches diameter, with highly polished exterior surfaces. These two cylinders are mounted on a rigid iron framework, and separated from each other by about one-eighth of an inch. They are gear-driven in opposite directions, at a velocity of six revolutions per minute. On the outside of each cylinder, at the top, and just coming into contact with it, is held a sharp knife. Between the two cylinders is placed a narrow trough pierced on either side with a longitudinal row of holes. The milk is fed into this trough, and sprays through the orifices onto the cylinder on either side.

Steam is admitted into the cylinders at a pressure of about 40 pounds, which gives a temperature to the outer surfaces of from 220 deg. to 230 deg. Fahrenheit.

The milk is sprayed continuously upon the hot cylinders, and the water is immediately evaporated and escapes in the form of steam through a ventilator mounted over the apparatus. The solid constituents of the milk remain in a uniform layer upon the polished surfaces of the cylinders, and are removed in a continuous sheet as the cylinders revolve, by the stripping knives, at the dairy of Messrs. Mignot & Plumey, Louviers, France. The dried milk is soft and friable and requires no grinding, being easily reduced to a fine uniform powder by being passed through a sieve.

The operation occupies less than thirty seconds, and a machine dries 70 gallons of milk per hour. It can be operated equally successfully with separated or with milk containing all or any part of its cream. One hundred pounds of full-cream milk yield about 12½ pounds of dry milk, containing about 30 per cent of butter, while 9 pounds of dry separated milk can be extracted from 100 pounds of liquid separated milk.

The paramount advantages of this product are its perfect solubility, which renders possible the rapid reconstitution of natural milk, with all its organoleptic properties—its assimilability, its perfect preservability, and its absolute sterility.

Owing to the high temperature of the cylinders, it might be thought that the albumen would be precipitated and the dry milk rendered insoluble and useless. But such is not the case. The addition of hot water of about 170 deg. F. to the dried milk causes it to dissolve instantly, without leaving any deposit. Furthermore, the odor and taste of the reconstituted milk are identical with the odor and taste of fresh milk. Chemical analyses made by experts have shown that no determinable changes take place in the milk solids. The average composition of the milk powder produced by drying full-cream milk is as follows:

	Per cent.
Casein	27
Butter-fat	28
Milk sugar	35
Milk salts	6
Moisture	4
	100

These are the same proportions in which the various nutritive substances exist in liquid milk.

But possibly the most important fact concerning the product is its complete freedom from bacteria, which constitute such a grave danger in milk. All the bacteria that are present in the liquid milk when it goes over the drying machine are completely destroyed, as Dr. Magill and other scientists, who have subjected the Just-Hatmaker product to extensive and exacting chemical, bacteriological, and clinical tests, have conclusively demonstrated. Germs cannot develop in dry milk. More than four hundred bacteriological examinations of it were made by the Carnegie Laboratory, by the Department of Health of New York city, by the Department of Bacteriology of New York University, and by the Department of Pathology of Cornell University, New York, and it was proved beyond any doubt that this dry milk is absolutely sterile when it comes from the drying machine. Living and virulent cultures of tubercular germs and of anthrax germs were furthermore introduced into milk, which was then put over the drying machine, and the dry resultant product was found to contain no living germs. It was cultivated for bacterial growth without any development, and guinea pigs were inoculated with it repeatedly without showing any pathological reaction whatever. That it remains sterile if protected from contamination by air bacteria was also shown by a box of the dried milk being sent round the world, and detained three weeks at Shanghai. Upon its arrival home, the powder was found to be absolutely sterile, stable, and in perfect condition.

In order to demonstrate the assimilability and physiological effect of the powder, a series of prolonged feeding tests were made in New York city during last summer, to determine these points. Under the supervision of officers of the Department of Health, 850 babies ranging from five days to two years old, and in average good health, were selected, for the most part from the poorer tenement house districts, and fed exclusively during the four hottest summer months upon this dry milk. Full cream-milk powder was used in part of the cases, but milk powder produced by drying mixtures of two-thirds full cream and one-third separated milk, or one-half full cream and one-half separated milk, was chiefly used. Sugar of milk was added according to the age of the infant, and to meet the ideas of the physician in immediate charge. The dry milk was left with the mothers either in a box or a sealed envelope, with directions to dissolve the prescribed quantity in hot water, and to give it to the infant at the times specified. It was imperatively ordered that any of the reconstituted milk that remained over after feeding should be thrown away. The results of this feeding of 850 infants, chosen from the poorer quarters of a great city, exclusively upon milk reconstituted from this dry milk, are unparalleled. Not one child died. With one exception all the children gained regularly in weight; one child lost 100 grammes in five days, but soon afterward re-established its good average. These practical experiments showed the important fact that the milk made from this dry milk does not clot in the stomach like ordinary milk, but in fine granular clots, which closely resemble those formed in human milk, and that its digestion is easy and complete.

The commercial advantages of this dry milk are obvious. It will keep indefinitely in an ordinary barrel or case. The expense and trouble of conveying and delivering milk in cans is dispensed with, as dry milk can be shipped in boxes or bags. It is lighter to handle, since the weight of dry milk is one-eighth of that of liquid milk, and it can be placed on the market in a variety of forms—compressed tablets, powder, or incorporated with chocolate and other foodstuffs—which renders it especially useful in numerous industries.

The cost and maintenance of the apparatus is small, and it occupies but little space. The total weight of the machine is four tons. It can be installed and operated in a space measuring 8 feet by 10 feet. The power that is requisite is from 4 to 5 horse-power, and about 840 pounds of steam at 40 pounds pressure is sufficient to dry 70 pounds of milk per hour. Furthermore, being quite automatic in its action, one operator can easily look after two machines.

This process is now in use in many of the best dairies in England, Ireland, France, Germany, Russia, Switzerland, Austria-Hungary, Italy, Australia, and the Argentine. It has been shown publicly at the Concours Ayncoli in Paris, at the great German Agricultural Show at Dantzic, at the Show of the Royal Agricultural Society of England at London, and at the show of the Royal Lancashire Agricultural Society at Southport, England, and has been awarded several special medals.

THE CHEMISTRY OF PATINAS AND PAINTINGS.

EVERY casting of iron, zinc, brass, copper, bronze, and even silver comes from the mold covered with a "skin" composed of various substances which have been formed by chemical action between the metal and the material of the mold. In most cases this skin must be removed, for it makes the casting unsightly and its material unrecognizable. It is usually taken off by "biting" or etching with diluted acids, alkalies, or other solvents of the metal, combined with diligent washing and scouring and sometimes with mechanical treatment which may even take the form of actual chiseling. The etching liquid, of course, does not act quite uniformly, but lays bare the more or less crystalline structure of the metal, so that the mere removal of the skin produces a porous surface which is often only masked and seldom entirely obliterated by the file and burnisher. Here, then, at the outset, is the commencement of the complex process which eventually results in the formation of a patina.

There are, however, products of art manufacture which are perfectly smooth when made and are endowed with great powers of resistance to mechanical influences but which, nevertheless, become rough with age.

I speak particularly of porcelains. Their surface is perfectly smooth, for it is formed during the slow cooling of the kiln by the amorphous solidification of the glaze, which was fluid during the firing, and whose mirror-like surface has not been ruffled by contact with any solid body.

But very few porcelains retain this smoothness permanently, for, aside from the scratches made by sandy dust, which is harder than the hardest glaze, there is always a difference in composition and consequently in thermal expansibility between the glaze and the underlying substance. If this difference is great enough to be expressible numerically, the glaze soon scales off and the object is entirely ruined. With such

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

grave defects in manufacture we are not concerned at present, but even slight differences between glaze and paste betray themselves by the "hair lines," or fine cracks, visible under a lens and often with the naked eye, which gradually develop in the glaze. Even when these lines are so fine that they cannot be distinguished with the aid of a strong lens, but only under the microscope, their steady accumulation may seriously affect the luster and durability of the object.

Glass, the surface of which very closely resembles that of porcelain, behaves in the same manner, but substances of very different character also undergo similar changes. Who has not noticed the infinitely fine lines with which old ivories are almost covered? Ivory has nothing like the hardness of glass or porcelain glaze, but it possesses extraordinary elasticity, which makes it well fitted to withstand pressure, blows, and other mechanical influences. This elasticity, which ivory shares with a few other substances, makes it a suitable material for objects like billiard balls, which could not be made as durable of other and much harder material. No ball of glass, porcelain or even bronze or cast iron could meet the demands made on a billiard ball for years and decades. An ivory ball remains round, smooth, and glossy though subjected daily to thousands of violent thrusts and collisions, but if an old ball is examined carefully with a lens its surface is found to be traversed by myriads of fine cracks. The surface of old ivory carvings is in still worse condition. These little fissures are due to the fact that cartilage, the chief constituent of ivory, gradually contracts and grows denser when exposed to the air. The change is confined to the superficial layer, the inner parts remaining unaltered in volume. Hence arises a surface tension which produces fine cracks like those which in porcelain result from a different cause.

Surfaces of any kind coated with oil paint, varnish, or lacquer change as ivory surfaces do and for the same reason. The superficial oil or varnish slowly hardens and contracts, partly through drying, partly through the action of atmospheric oxygen, while the lower layers, protected by the upper, remain unaltered, and the solid base also retains its original dimensions. The result is tension, followed, slowly but surely, by fine cracks which multiply with the years.

These facts, and others that I have discussed previously, seem to justify the assertion that there is hardly a substance that will not show the steadily increasing effect of years of exposure to ordinary terrestrial influences. The usual results are roughness and porosity of the surface due to various causes.

The question suggests itself: What visible alteration is produced in works of art by this roughening, and how does it give rise to the subsequent chemical process of patina formation?

Especially striking is the loss of luster which accompanies the roughening. Only quite new and freshly polished objects possess the high gloss which persons of artistic sensibility so greatly detest for the very reason that it is an infallible proof of newness. A rough surface, even if its inequalities are microscopic in size, lacks the sheen of a mirror and disperses light in all directions from millions of tiny facets. Thus the contours of both lights and shadows become softened and the transitions between them less abrupt. Then only does the work become true to nature and life; for the surface of the earth itself, regarded as a whole, is not smooth but is roughened by millions of small inequalities which give to every natural phenomenon, every landscape, and every living creature, its characteristic softness, delicacy, and play of light, shade, and color. Even the smoothest thing on earth, the surface of water, is not smooth as a whole, but is roughened by countless waves of various sizes and shapes. Therein lies the charm of water in a landscape, the witchery of the ocean. A motionless water surface appears unnatural—"oily."

Therefore it is no mere pose or aping of a transient fashion, but a perfectly rational feeling born of conscious or oftener unconscious observation of nature, that rejects the high polish and "oiliness" of brand-new works as unreal and consequently inartistic.

The roughness of surface which an old work acquires with the years, like a patent of nobility, may, however, have another effect than the beneficial toning down of the aggressive and insolent glitter of newness. When roughness has developed into actual porosity it may seriously affect the color of the object, chiefly because the pores become filled with air, for light falling on finely divided air is totally reflected.

The effect differs according as the object is illuminated from in front or from behind. In the former case the color is made paler by the addition of white light; in the latter, white light is subtracted, making the color darker. Everyone who has worked with the microscope will understand this at once, for he knows that the air bubbles which so often creep into the field of the instrument look like silver bullets by reflected, and like drops of pitch by transmitted light. Illustrations of the same law may be observed at the seashore. The foam that crowns the incoming breakers is white because it is filled with countless air bubbles, but when seen against the light it is as black as pitch and a bather submerged by a foaming wave finds himself in darkness.

For this reason an old Venetian goblet or a medieval "willekumm" appears gently clouded and very different from our quite transparent modern glasses, which will also—if they escape the housemaid—change greatly in three hundred years. Medieval glass, even when new, contained more air than the modern product and the fine bubbles scattered through it have an effect like that of the innumerable microscopic cracks and scratches of the surface. In some modern glass, notably the "cathedral" window glass used in public buildings, air bubbles are purposely introduced, but they give only part of the designed resemblance to old glass. The other and better part can be produced by time alone.

In view of the total reflection of light by air occluded in porous substances, it is evident that works of art with opaque surfaces, whose effect depends entirely upon reflected light, must become paler with age, and such is found to be the fact. We see the result in many frescoes of various periods which are continually growing paler and more chalky. The most celebrated example, and a lamentable proof of the mortality of even the most immortal work, is the "Last Supper," by Leonardo da Vinci in Milan. In this masterpiece of one of the greatest of the great Cinquecento painters, the cracking and crumbling of the surface are going on so rapidly that their progress can be noted in a lifetime. When I saw the picture in my youth it was still possible to form a conception of its original beauty but it is not possible now, and we are indebted to reproductions for the knowledge of what we have lost. Here patination has degenerated into decay.

What is the effect of age on oil paintings? These afford an illustration of the difficulty of determining whether we see objects by reflected or transmitted light. Anyone who had not considered the subject would say that in regard to oil paintings and paintings in general only reflected light need be taken into account, but the statement would be erroneous. Most painting methods, and oil painting above all others, are based upon the fact that light penetrates the layer of paint to a greater or less depth, and thence returns, filtered by selective absorption. For this reason the artist fills the interstices between the particles of pigment with strongly refracting varnish. If he should leave them filled with totally reflecting air, his work would be "chalky"—a far from laudable character in a painting. He produces his varied effects by changing the proportions of oil and pigment, painting thinly or thickly and using translucent "glazing" colors or dense, opaque pigments. Hence arises what is called the "light" of a picture, the warm living tone that seems like an echo of nature and makes us wonder how Titian and Rubens were able to create, with the few pigments at their disposal, color symphonies whose unsurpassed beauty rejoices our souls to-day.

Now, as the effect of an oil painting depends very little on reflected light, but almost entirely on light which has traversed a layer of pigment—in viewing an oil painting the observer must station himself so as to avoid the light reflected directly from the picture—the painting is not, like a fresco, made paler by the fine cracks brought by age, but it becomes darker, as the glassiness which mars our enjoyment of the new work is gradually replaced by a veil formed by the innumerable microscopic fissures of the surface. The effect is the same as in old glass and is best described by the untranslated word *mellow* which the English apply, quite properly, both to a fine old wine and to a priceless Gainsborough or Reynolds. The process, which takes place in all paintings, more or less rapidly according to the method of their production, is a typical patina formation, though still purely physical. The result is called, not patina, but "gallery tone." This veil thrown by time over the art of the past may either beautify or conceal, like other veils. In every gallery hang pictures in which the gallery tone has long lost the character of an embellishing patina—pictures whose original worth can only be guessed, which look as if they were painted with bitumen on a ground of pitch. The great Pettenkofer, who investigated this subject many years ago at the instigation of the art-loving King Ludwig I. of Bavaria, discovered a method of "restoring" such pictures and giving back to them, for a time at least, their pristine light and color, by exposing them for some days to the action of turpentine vapor, which swells and welds together the hardened varnish, closes the fissures, and expels the mischievous air.

Superficial cracks and pores may, however, produce a patina quite independently of the occluded air.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Dr. O. N. Witt, in Prometheus.

A ROMANCE OF SUSPENDED JUDGMENT.

ON the island of Elba there occur two minerals which, from their peculiar association, were named castorite and polluxite, in fanciful allusion to the devoted twins of ancient mythology. Castorite is a variety of petalite, a double silicate of aluminium and lithium. Polluxite is—here is where the romance comes in. In 1846, Plattner, a careful specialist in blowpipe analysis, an art now almost neglected, examined this mineral polluxite. His published report stated the composition as a hydrated silicate of aluminium, sodium and potassium; the only alkali metals known at that day were lithium, sodium, and potassium. There was nothing specially remarkable about his analysis except that the sum of the ingredients, instead of approximating the theoretical 100 per cent, amounted to only about 92 per cent. The margin of error was too great to pass unnoticed, and it did not. Critics were not wanting. Even our great and genial Dana the elder, in his mineralogy, noted the glaring discrepancy and gave gratuitous explanation therefor. But in the little storm of controversy—for the mineral was rare—Plattner was cool, intelligent, and candid. He had no explanation to make for the missing 8 per cent. But he insisted on the general accuracy of his work and his result. What self-control it demanded may be imagined, for the **honest** scientist does not rashly blunder into published **absurdity**. But Plattner held his peace—he trusted his own work, and it must be right. A charlatan would have burned his figures; or, if publishing, he would have "cooked" them up to 100 per cent. Not so Plattner; he waited the vindication of scientific method. Along in the sixties, the scientific world was electrified by the truly wonderful discoveries of the then-new spectrum analysis. Among the noted finds were two new alkali metals, rubidium, the rosy-, and cæsium, the blue-lined spectrum-maker. Cæsium was identified in polluxite; it makes up 30 per cent of that mineral. Then Bunsen, the just, went over the old calculation of Plattner, showed where the veteran had honestly mistaken the unknown high-atomic-weight element cæsium for sodium and potassium with their lower atomic weights; and further showed that a re-calculation of Plattner's original figures gave a result that is still approximately correct. The illustration is striking but not solitary in the history of chemistry. The lesson is too obvious to spoil by comment. The example of rectitude is undying.—The Engineering and Mining Journal.

ENGINEERING NOTES.

Of the Parsons steam turbines, about 1,000,000 horse-power are already in use; of the Laval turbines, about 3,500, with a total of 100,000 horse-power; of Curtis turbines, about 300,000 horse-power; of the Rateau, 15,000 horse-power; and of the Zoelly, 20,000 horse-power are in service.

Mechanical appliances are coming more and more in evidence in the business office as their labor-saving qualities are recognized. A calculating machine is one of these time-saving devices which not only saves time but which insures accuracy of results. The latest development in this line is the addition of an adding attachment to an ordinary typewriter, which not only totals a column of figures but acts as a check upon the accuracy of same. When the typewritist has written the various items of a bill, the sum total is indicated on the adding wheels and is typewritten the instant the items are completed.—Machinery.

The almost universal practice of applying belts to machines requires that as the belt grows slack a piece shall be cut out, to take up the slack. This practice not only wastes the belt, but requires that the end cut off shall be carefully squared up and new belt holes punched in it. One firm, according to Machinery, follows a different practice. They deliberately cut their belts too short, when they are first applied to the machines, by a length of a foot or 15 inches. This must, of course, be filled in by an extra piece. When the belt grows slack this piece is removed and a shorter piece inserted instead. A variety of widths and lengths is kept in the toolroom for this purpose, and when a machine operator wishes to shorten his belt, he determines about how much slack needs taking up, and calls at the toolroom for a piece that much shorter than the one already in the belt. The old piece is returned to be used again as occasion requires.

An invention which appears to have a great future before it, has recently been tested in several English collieries and is being introduced to that section of mining engineers who are under the necessity of blasting in coal. There can be no doubt that explosives of any class have not yet provided us with an ideal agent for use underground. Unless under strict supervision they constitute a serious element of danger, especially if gas be present, and the accompanying fumes are at least a source of annoyance to workmen. In addition explosives often shatter the coal so that a large amount of dust and unsalable material are produced, reducing the necessary margin which must exist between cost and sale values. Though there are many collieries where, owing to the bulk of the coal being used for coking purposes, large stuff is not so necessary as at a house coal pit, one can generally assume that the large coal contains a much less amount of impurities, and these impurities of shale, etc., will be more easily removed than in the case of the smaller product. Large coal passed through the crusher almost invariably yields coke of above the average quality of that produced from "run-of-mine," or unscreened, coal. It will, therefore, be recognized that any invention having for its object the production of large coal is worthy of the attention of the mining community. The introduction of coal cutters has increased the demand for an efficient method of breaking down the coal, and it is for this class of work that the hydraulic mining cartridge has been used in England.—Mines and Minerals.

A system for continuously siphoning an Ontario quarry, instead of depending wholly upon the dam and spillway, was desired. The first attempt was made with a galvanized sheet-steel siphon about eight inches in diameter. There was an 8-foot lift, followed by a practically horizontal run of 200 feet over level land, and that was followed by an 18-foot fall. The pipe was carefully made and tested for air-tightness, and was installed in position. The lower end of the pipe was sealed, and the pipe itself was filled from a cock at the top. As soon as the lower gate was released and the current started, the entire pipe collapsed, as a result of atmospheric pressure, the pipe not having sufficient strength to maintain the vacuum necessary to lift the desired volume of water. The next experiment was made with a siphon of two-inch iron pipe, following the same course as the former siphon. It operated satisfactorily during the first day, but on the next morning it was found to be stopped. The process of stopping and filling was again resorted to, and the siphon acted

satisfactorily during the day, but on the following morning the same conditions as on the day before were encountered. The conclusion was then come to that there had been an accumulation of air in the pipe as a result of the gradual separation of the air which was in the water, and subsequent experiments proved the truth of this hypothesis. The problem was solved by attaching a reducing elbow at the top of the 18-foot section, reducing the diameter of the pipe from that point to its lower end to one and a quarter inches. This reduction of the diameter of the pipe accelerated the flow of water to such an extent that the air which had accumulated at the elbow and at the top of the 18-foot section in the original installation could no longer accumulate. No further trouble was experienced.—Fire and Water Engineering.

SCIENCE NOTES.

Considering the enormous amount of metallic and mineral products brought out and sold on chemical analysis, it is surprising, says the Mining Magazine, that only spasmodic efforts have been made to establish uniform methods for technical analysis. The urgent need for such a standardization of analytical methods has, however, been quite generally recognized.

It is stated that Emile Wenz, of Reims, France, has recently applied kite-photography with success to geological pictures, and it is predicted that the field geologist of the future will find a kite and its camera essential to his outfit. M. Wenz succeeded in taking good photographs from a height of over 650 feet, and found them very valuable in the production of maps.

The possibility of large practical results from botanical investigations along agricultural lines seems to be particularly promising at the present time, probably because so many botanists are directing their attention in this direction. What the future has in store for the farmer of this country, because of the researches now being carried on in plant pathology, plant physiology, soil bacteriology, and other branches of botany, can only be conjectured, but that much of real value will be forthcoming there can be little doubt. In no other field are the opportunities so great; in no other way are the practical returns of botanical investigation so sure.

When the farmer is made to realize that the soil upon which he is so dependent is not dead and inert, but a living, changing thing, the laboratory in which some of Nature's most wonderful miracles are performed, he will be more ready to accept help and advice from a man who may not know how to plant and reap, but who understands the nature of the growing and the fruiting and the factors controlling them, as only one who has given himself to searching for botanical truths can know them. And when such knowledge applied by the farmer means all the difference between success and failure, an increase of 100 to 1,000 per cent in his crops, the growing of new plants in new ways, the successful combating of ruinous diseases, the conservation of the real worth in the manure pile instead of allowing all its fertilizing power to be wasted into the air—these and many other practical results will at no distant day establish botanical research as one of the most necessary and beneficial aids to the most important industry in the world.

A description of the formation of the great peat bogs was given by Prof. Weiss in a lecture to the members of the Manchester Field Club. He showed how bogs originate in a hollow place in which water collects. In the water the spores of the bog moss germinate, and gradually the moss chokes up the pit, just as various water-plants choke up ponds. The bog moss bunches itself together and rises above the surface of the water. Chat Moss was originally such an expanse of soft, spongy bog moss, on the surface of which plants like the insectivorous sundew flourish. As the moss grows dead vegetable matter accumulates on the bottom of the hollow, and after it has accumulated to a certain extent, instead of decaying completely and becoming soil, the decay is arrested owing to the presence of the large quantity of water. That is the beginning of the formation of peat. Peat is found in two forms—an upper layer of fibrous peat which is dry in the summer, and below that a layer of soft moist peat. In many cases the peat-bed spreads beyond its original hollow and encroaches on the surrounding vegetation, which it kills by excluding the air. Often forests are killed and submerged by this means, as in some parts of Germany, where in low-lying districts forests have been eaten away by the peat bog. During some recent excavations near Oldham 15 feet depth of peat was found, the bottom 3 feet of which was filled with the trunks of trees. A whole forest had been cut down and buried. In some of the peat bogs of Ireland remains had been found of three successive forests which had been killed and submerged by the bog. After one forest had been buried in the bog, soil was formed on the top, owing, perhaps, to some change in the drainage of the land, and trees again grew, till they were in their turn overcome by the encroaching bog.

A CORRECTION.

In our issue of February 4, 1905, we published a translation from La Revue des Produits Chimiques describing a composition for removing paint and varnish and the method of its preparation. We learn that this composition has been patented in this country, for which reason it cannot be made by any one without the permission of the patentees. We, therefore, take this opportunity of calling the matter to our readers' attention.

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